AD-776 389

RIFLE-GAS LAUNCHED GRENADE CONCEPT

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September 1973

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: R-RR-T-3-74-73	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER: AD 776 389	
4. TITLE (and Subtitle): Rifle-Gas Launched Grenade Concept	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Robert E. Duncan	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Small Arms Weapon Systems Directorate, GEN Thomas J. Rodman Laboratory, Rock Island, Illinois 61201	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 1W562604A621-01
11. CONTROLLING OFFICE NAME AND ADDRESS: Small Arms Weapon Systems Directorate, GEN Thomas J. Rodman Laboratory, Rock Island, Illinois 61201	12. REPORT DATE: September 1973
	13. NUMBER OF PAGES: 61
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Firearms, guns, grenade launchers, cartridges, projectiles, grenades, propellants, small arms ammunition, gun mechanisms, gun components, weapon firing mechanisms, gun launchers

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The report describes a feasibility study on a novel approach for launching a 40mm grenade. The study was undertaken with the goal of conceiving and developing a future grenade launcher which would be applicable to the Future Rifle System Program. This program advocates a weapon system which is a combination of both a rifle (point fire) and a grenade launcher (area fire). To maximize integration of the launcher to the rifle design, it was theorized to utilize rifle propellant gases to launch a grenade projectile. The

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20. Abstract Continued:

proposed concept would provide for reduced grenade ammunition costs, reduced number of launcher component parts, lighter total weapon system weight, and more grenade rounds per combat load. A concept which contained all of the above features was generated, designed, fabricated, and tested. The report describes the various facets which went into each stage of its development. Feasibility of the proposed concept was demonstrated by the final achievement of muzzle velocities comparable to standard 40mm grenade launchers.

ABSTRACT

The report describes a feasibility study on a novel approach for launching a 40mm grenade. The study was undertaken with the goal of conceiving and developing a future grenade launcher which would be applicable to the Future Rifle System Program. This program advocates a weapon system which is a combination of both a rifle (point fire) and a grenade launcher (area fire). To maximize integration of the launcher to the rifle design, it was theorized to utilize rifle propellant gases to launch a grenade projectile. The proposed concept would provide for reduced grenade ammunition costs, reduced number of launcher component parts, lighter total weapon system weight, and more grenade rounds per combat load. A concept which contained all of the above features was generated, designed, fabricated, and tested. The report describes the various facets which went into each stage of its development. Feasibility of the proposed concept was demonstrated by the final achievement of muzzle velocities comparable to standard 40mm grenade launchers.

FOREWORD

Mr George L. Reynolds, GEN Thomas J. Rodman Laboratory and Dr Kenneth Richards, Lockheed Electronics Co., formerly of the GEN Thomas J. Rodman Laboratory should be given special credit for their significant contribution to this study. Mr Reynolds was responsible for the design of the fixture, while Dr Richards performed the mathematical analysis of the concept.

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INTRODUCTION

Early in 1970, a program was undertaken with the goal of conceiving and developing future grenade launchers. Drawing upon some of the rationale endorsed by the Future Rifle System Program, one approach considered was a weapon system which contained two weapon elements; a rifle and a grenade launcher. It was observed that one way to obtain maximum integration of area fire and point fire into one weapon would be to use as many of the existing rifle parts in the design and operation of the launcher as possible. It was then theorized that if we could employ the same principles used in the gas system for automatic weapons to launch a grenade (i.e., tapping off gas pressures) then we could achieve a high degree of integration and also at the same time eliminate the need for a grenade cartridge case. This would provide for reduced ammunition cost, reduced number of launcher component parts, lighter weapon system weight, and more grenade rounds available per combat load.

In mid 1970, a concept was generated which contained all of the features described above. The area fire component was comprised basically of a barrel preloaded with two or more grenade projectiles. The source of energy for launching the projectile was obtained by tapping off a portion of the propellant gases of the point fire weapon component. To fire a grenade, a conventional rifle cartridge had to be fired. The launcher was conceived as a multi-shot, semi-automatic device, lightweight and compact with speedy operation, and of simple construction. A selector switch was included in the weapon design

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which provided for a choice between area fire and point fire.

In about mid 1971, new impetus was given the effort and the concept was revived and examined in-depth. A preliminary mathematical analysis was made to determine the feasibility and also predict the desirability of fabricating a test fixture. The analysis proved favorable and a 40mm, single shot test fixture was designed and fabricated. With the fabrication of the test fixture, testing was commenced to determine the feasibility of the concept. The achievement of comparable muzzle velocities between the gas launched concept and a standard 40mm system was established as the criteria for feasibility. It was concluded that since the same standard projectile was used in both weapons, comparable muzzle velocities would also give comparable exterior and terminal performance characteristics.

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RESULTS

Based on a favorable preliminary mathematical analysis of launching a grenade solely by rifle propellant gases, work was initiated in-house on the design of a firing fixture for determination of feasibility. With the objective of the effort being the demonstration of feasibility, 40mm was selected principally due to availability of comparative data from the M79, 40mm, Grenade Launcher. The design of the firing fixture can be noted in Figure 1. The M16A1 Rifle was selected as the point fire element of the weapon system concept. Photographs of the fabricated test fixture can be noted in Figures 2, 3, and 4.

From August 1971 to March 1972, the 40mm gas launched grenade concept went through successive cycles of test, evaluation, modification, and retest. This effort culminated with the achievement of muzzle velocities comparable to those produced by a M79, Grenade Launcher. This achievement met the feasibility criteria set for the concept. Additionally, the testing also examined other features whose interaction played a role in the resulting muzzle velocities. These features were the effects of engraving forces, obturation, gas port size and location, and initial chamber free volume. The muzzle velocities of the rifle, its corresponding operation, and the resulting recoil forces were also monitored during the testing.

In the last series of rounds fired, the fixture produced an average muzzle velocity of 222 fps. This compared favorably with an average muzzle velocity of a M79 fired at the same time of 231 fps.

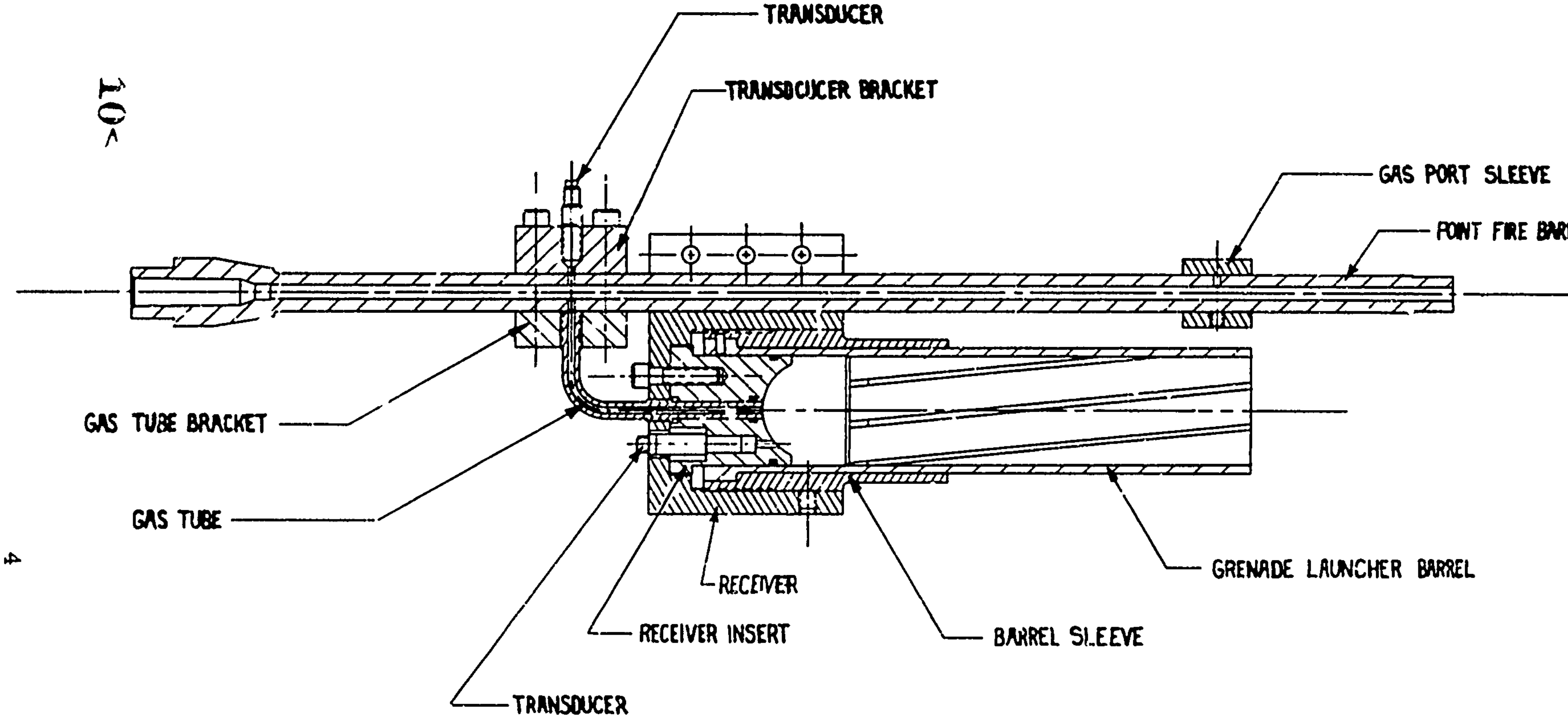

Figure 1: Cross Sectional View of Gas-Launched Firing Fixture

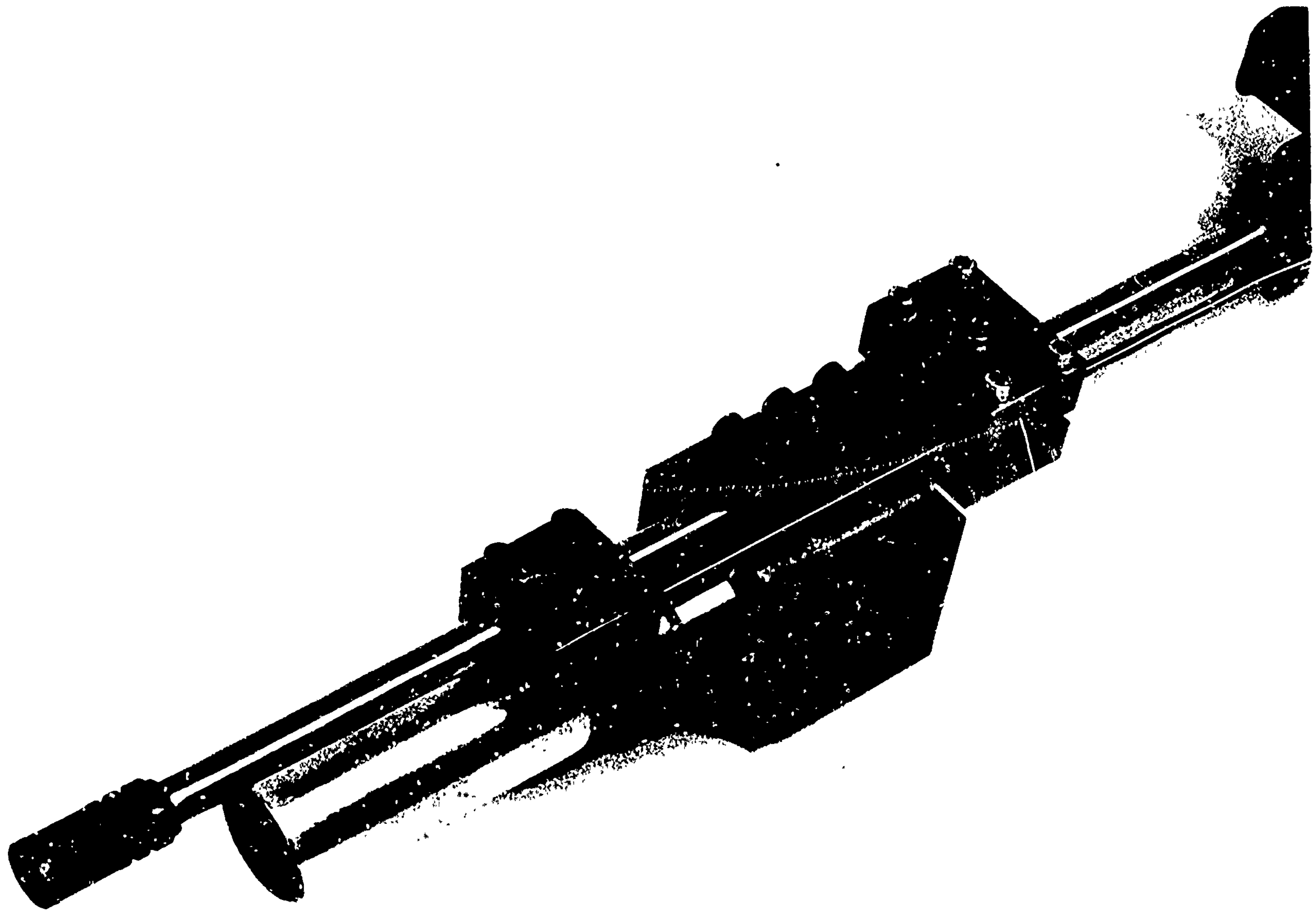

Figure 2: Close-Up View of Test Fixture Mounted on Modified M16 Rifle

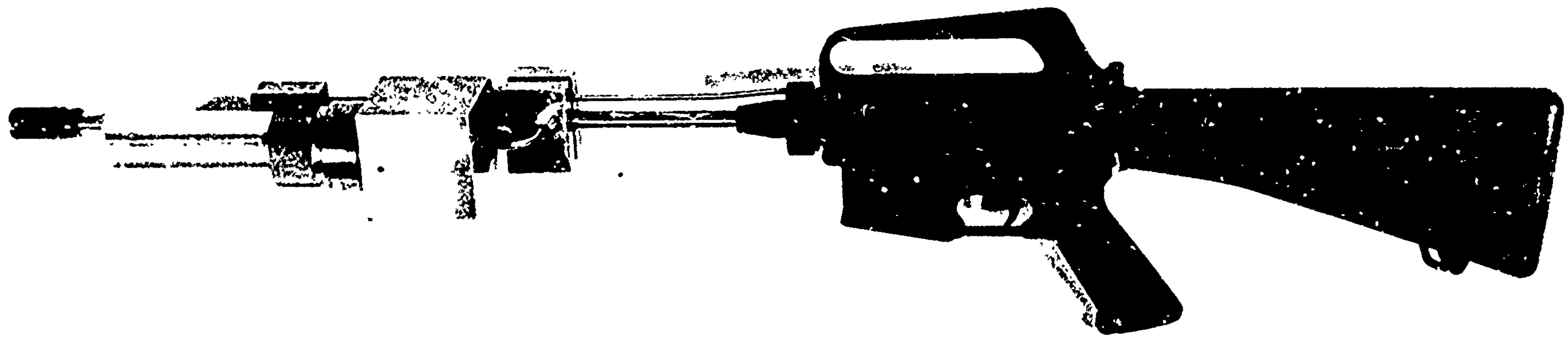

Figure 3: Left Hand View of Test Fixture

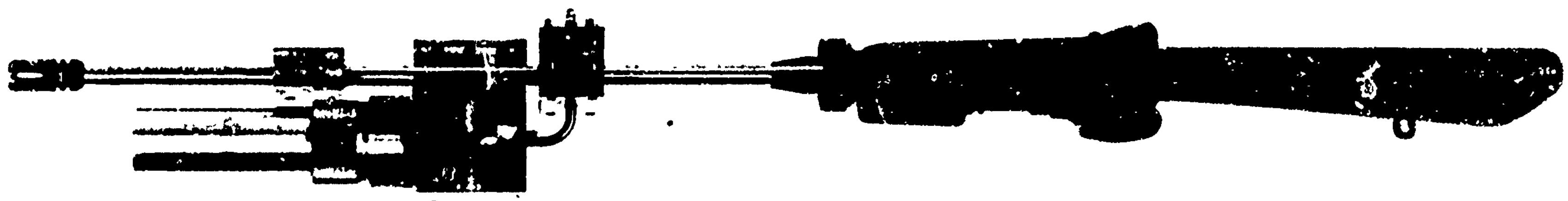

Figure 4: Top View of Test Fixture

As the grenade velocity increased, due to design improvements, it was noted that effects of projectile engraving on muzzle velocity decreased. This was observed through the use of standard and pre-engraved projectiles. At maximum velocities attained, there was only a 0.6% increase attributable to using pre-engraved projectiles rather than ones that were not pre-engraved (See Figure 5). Obturation effects were not monitored for the entire test but at the lower operating pressures and velocities, special attempts to completely seal the bore did produce approximately 10% increase in muzzle velocity.

The math model used in the initial analysis stage indicated that a gas port size of .091 inches diameter located 12.70 inches from the rifle muzzle would produce acceptable results. However, during testing, it was found that this combination did not provide sufficient gas flow and pressure. The next development stage moved the gas port 2 inches closer to the rifle chamber. Sufficient grenade muzzle velocity was still not obtained. Final modification was to triple the cross-sectional area of the launcher gas tube. The result was a gas tube diameter change from .091 inches to .166 inches. This final configuration did produce the high muzzle velocities noted previously. Within the limits of the test, little effect on grenade muzzle velocity could be attributed to the magnitude of initial free volume of the launcher chamber. The test plan noted in Appendix B describes the procedure used to determine this result.

When designing the firing fixture to mount on the M16 barrel, special

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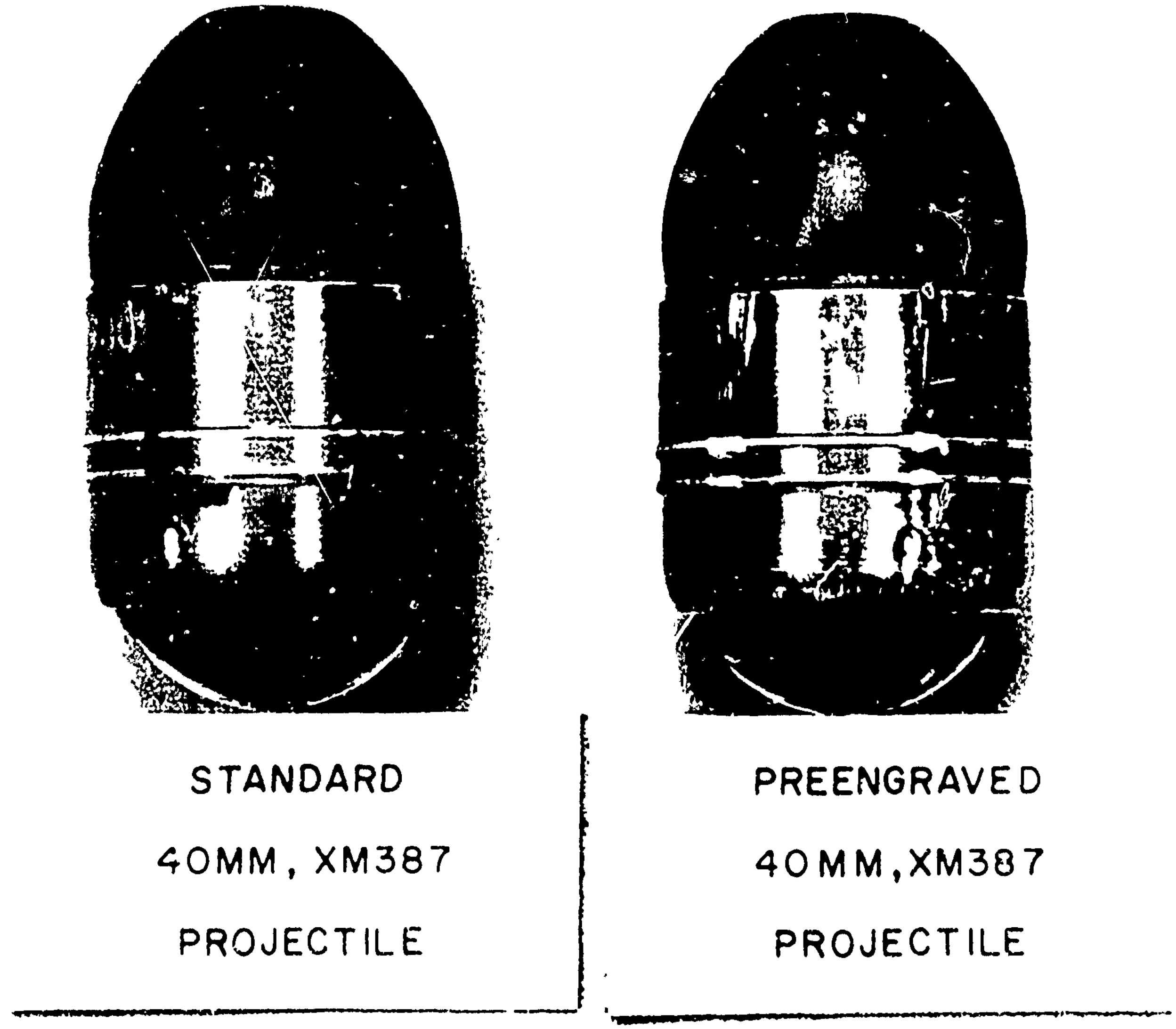

Figure 5: 40mm Inert Test Grenade Projectiles

attention was made not to modify the M16 gas tube. One of the objectives of the test was to determine if launching the grenades as proposed would adversely affect the operation of the rifle. One malfunction that was persistant during the entire test was failures to eject the spent M16 Rifle cartridge. High speed motion pictures (3500 frames/second) showed that the case was extracted but insufficient travel prevented ejection.

It was a general trend that as the muzzle velocity of the grenade increased, the muzzle velocity of the M16 bullet decreased. This ranged from 3200 fps down to 2900 fps. These particular values can be noted in Appendix C; Test Results. Recoil forces of the rifle/launcher test fixture were also measured. However, due to the test set-up, this was more a qualitative comparison rather than a quantitative determination. Generally speaking, the firing of the grenade as proposed in this report increased the loads seen at the shoulder by a factor of 2 to 2 1/2 of those of a conventional M16A1 Rifle. This is attributable to the double impulse firing of both the rifle cartridge and launching the massive grenade.

The noise levels for the system was also recorded. There was no appreciable difference between the fixture firing and a standard M16 Rifle.

Finally, blank ammunition was fired in the modified M16 with a XM15 blank firing attachment to determine the feasibility of launching the grenade. The results gave minimal velocities (less than 100 fps). These can be noted on Page C-4.

CONCLUSIONS

An overall conclusion drawn from the study is that the theory of launching a 40mm grenade projectile solely by the use of surplus rifle propellant gases is valid. This was demonstrated by the attainment of muzzle velocities comparable to a standard conventional grenade system.

At this point in the study, it appears that the concept discussed in this paper offers a method of improving the cost/effectiveness of the standard system. This could be achieved through a reduced cost of a cartridge by eliminating the need for a grenade cartridge case. Furthermore, with the elimination of the cartridge case, a reduced bulk would be realized and thus more rounds could be carried per combat load.

Even with these significant features to be gained, there is still one major question that has to be addressed before full acceptance of the concept is possible. It is the question of the simultaneous launch of two projectiles - a rifle projectile and grenade. The problem lies in the trajectory angle. In order to reach maximum grenade range, the rifle/launcher weapon system has to be elevated to approximately 40 degrees. Unfortunately, this also gives maximum range for the rifle projectile which has about 6-7 times the range of the grenade. In effect, the rifle projectile goes long past the intended target into an unknown or unintended region.

DISCUSSION

A. The Concept:

The study discussed in this report emanated from a concept generated at the US Army Weapons Command in mid 1970. The proposed idea advocated close integration with and utilization of the rifle mechanism for the design of the grenade launcher. Figure 6 shows the concept concerned. The mode of operation is as follows:

1. A selector switch on the rifle stock is used to select either the area fire (grenade) or point fire (rifle) mode of operation.

2. When the area fire mode is selected, a valve system is turned, via linkages, so that the grenade gas port is uncovered.

3. A magazine preloaded with two or more grenade projectiles has been attached to the grenade receiver. The initial barrel position allows for alignment of the gas ports.

4. To fire the grenade, the rifle trigger is pulled and a standard ball rifle cartridge is fired. As the rifle projectile passes the grenade gas port, the expanding gases flow into the launcher chamber behind the forward grenade projectiles. This provides for launch of the projectile.

5. The grenade firing impulse causes the barrel to shear a retaining lip and allows the barrel to set back to its rearmost position. This movement closes off the forward gas port and uncovers the rear one. The second round could then be immediately fired by pulling the rifle trigger again and firing another rifle cartridge.

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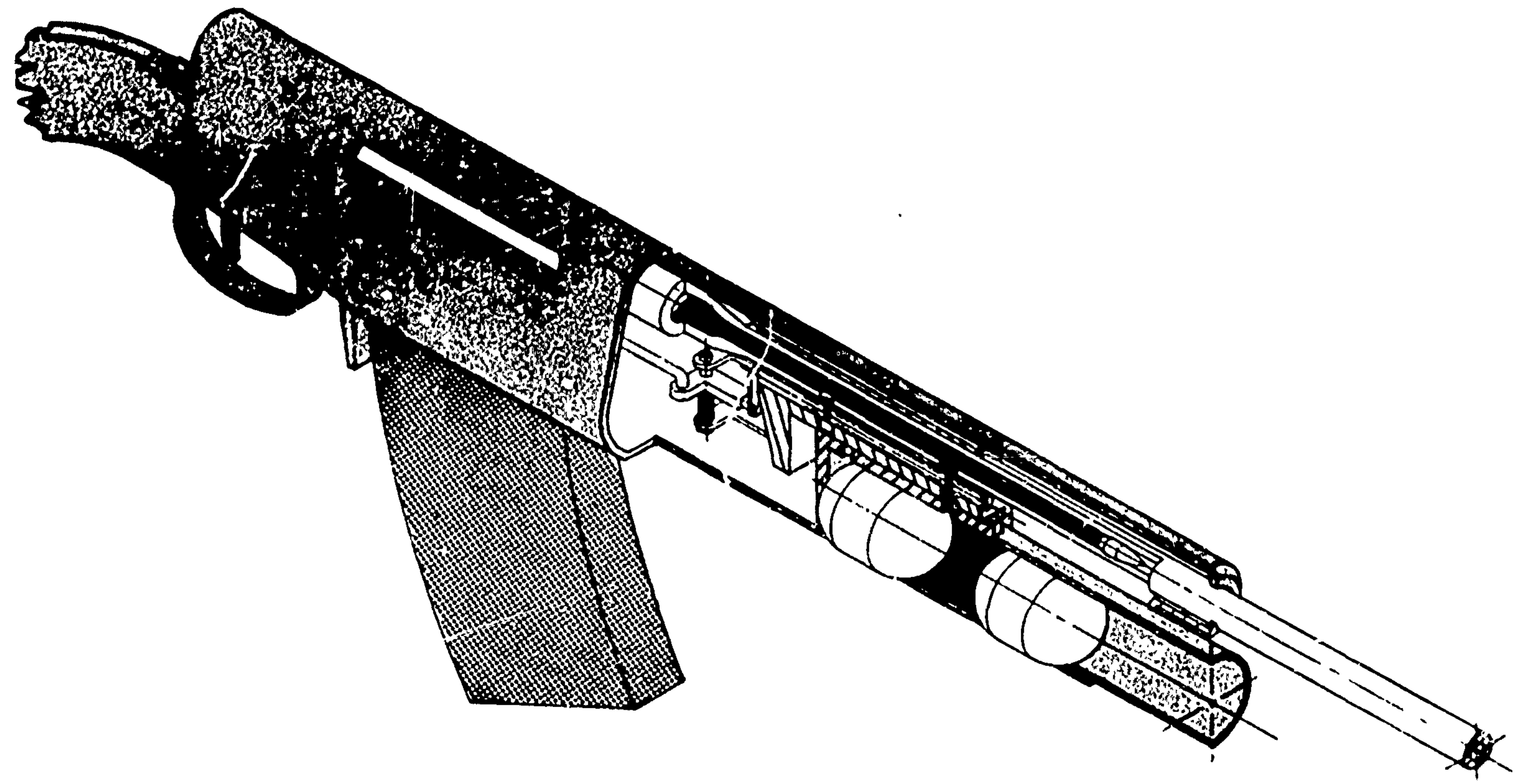

Figure 6: Multi-Shot Gas Launcher Concept

6. When the point fire mode is selected, the rotating valve closes off both grenade gas ports Therefore, when the rifle is fired, only a rifle projectile exists the bore.

To support the concept, a mathematical analysis was undertaken in mid 1971 for determining the theoretical feasibility of the approach. This approach is discussed in the next section.

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B. The Mathematical Analysis:

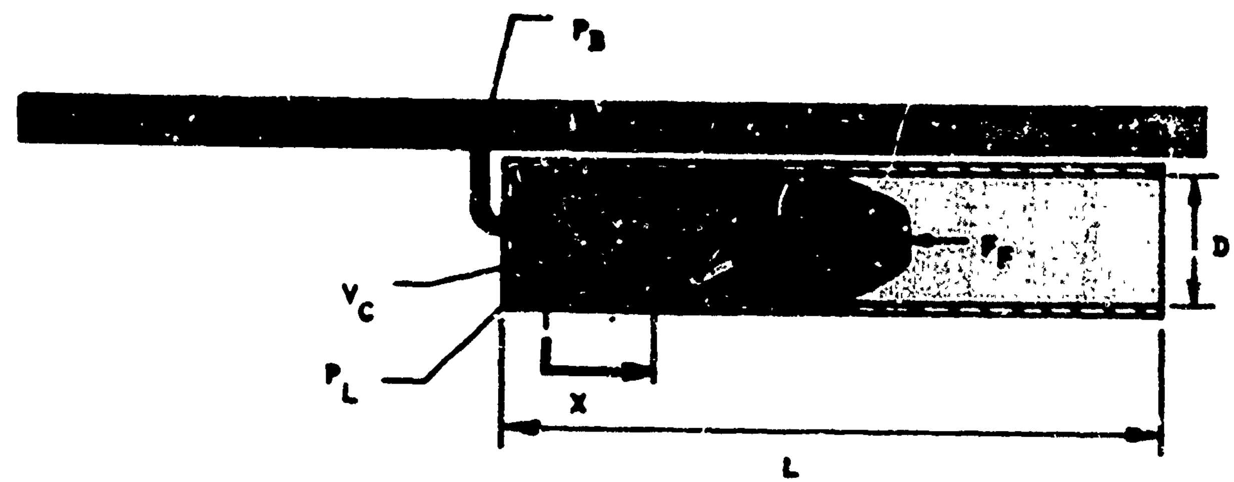
The detailed mathematical analysis undertaken to determine feasibility of the approach consisted basically of an interior ballistic program. The analysis was performed on a simplified design rather than the multi-shot concept originally conceived. Figure 7 is a schematic representation of the math model. The analysis considered in-bore time, grenade position, grenade muzzle velocity, launcher bore pressure, rifle bore pressure, grenade frictional forces, resultant grenade forces, and net grenade muzzle impulse. The program also examined grenade barrel length, grenade bore diameter, chamber volume, gas port diameter, number of gas ports, grenade weight, and gas efficiences. A list of some of these parameters can be noted in Table 1. A printout of the program can be noted in Appendix A.

Based on the input characteristics, the feasibility of each set of conditions was determined primarily by the resulting muzzle velocity. Close coordination was maintained between the design engineer and the analyst so that exercise of the math model would produce design parameters.

The above list of characteristics include not only input values but also outputs. The determination of the values for the inputs in some cases were obtained from experience plus existing systems. However, in some cases special studies had to be run. The value for the grenade in-bore time was obtained from a pressure-time curve for the 40mm round. The grenade position was one of the values calculated in the program as was the grenade muzzle velocity. The launcher bore pressure was a

(Continued on page 18)

AREA LAUNCHER MODEL



INPUT DATA

P_B - RIFLE BORE PRESSURE AT GAS PORT

F_F - AXIAL COMPONENT OF FRICTION AND ENGRAVING FORCES

L - LAUNCHER BARREL LENGTH

D - LAUNCHER BORE DIAMETER

V_C - LAUNCHER CHAMBER VOLUME

M_G - MASS OF GRENADE

CALCULATED DATA

P_L - LAUNCHER BORE PRESSURE

F_P - RESULTANT PRESSURE FORCE ON GRENADE

Figure 7: Schematic Representation of Math Model

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TABLE 1

INPUT CHARACTERISTICS FOR MATH MODEL

Input information for gas launched grenade firing fixture

1. Length of Rifling: 5.85 in.

2. Port and tube diameter - .091; Port and tube length - 4.13

3. Initial volume:

   a. Tube .0256 in^3 (tube diameter .091, length 3.96)

   b. Projectile skirt: .129 in^3

   c. Total of a and b: .156 in^3

   d. Initial volume for various linear components of volume (includes 3c above)

      (1) 0 in. - .156 in^3

      (2) .16 in. - .188 in^3

      (3) .125 in - .410 in^3

      (4) .250 in. - .664 in^3

      (5) .375 in. - .919 in^3

      (6) .500 in - 1.173 in^3

      (7) .625 in - 1.427 in^3

4. Length of free bore. (Initiation of rifling is used as reference point. Positive sign indicates engraving).

   a. - .130 in.

   b. - .062 in.

   c. .000 in.

   d. + .062 in.

   e. + .130 in.

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calculated figure based on in-put rifle gas pressure, gas efficiency, and volume considerations. Values for the rifle bore pressure were obtained from M16 P-t data obtained from Frankford Arsenal. The P-t curves were for a series of positions down the bore of the rifle which gave a collective set of data for each rifle shot. A P-t curve was selected whose position nearly proximated the location of the grenade rifle port. These data can be found in Frankford Arsenal Report Number R-2066, "Study of the Pressure Distribution Behind the M193 Projectile When Fired in the M16 Rifle Barrel" dated January 1973. The net grenade muzzle impulse along with the resultant grenade forces were calculated figures. One major factor effecting these values was the in-bore frictional forces. In order to determine these, a special study had to be run. A force-distance curve was generated for the projectiles as they were pushed through a 40mm barrel. Two typical curves for the engraving and frictional forces can be noted in Appendix E. In Figure 9, the two high initial peaks represent engraving of the two rotating bands. The cross head on the Instron Test Machine was run at speeds of .2 in/min. In Figure 10, the cross head was run at 20 in/min. The high speed was used to simulate high rates of loading experienced by the grenade when fired. Even though the test machine speed was quite low compared to the actual conditions; it did give some insight into the effects of loading as a function of speed. Generally speaking, as the loading increased, the peak values decreased. This ranged from 950 lbs down to 600 lbs for loading rates of .2 in/min up to 20 in/min respectively.

Additionally, as the rates increased, the initial peaks smoothed out. This can be seen by comparing Figures 9 and 10. In Figure 10, the second major peak probably arises from a constriction in bore of one form or another. In addition to indicating the force/distance curve for engraving forces, it also could serve as a histogram of the bore diameter and condition over its entire length. The very last peak is at the muzzle end of the barrel indicating projectile ejection. The resulting curves were approximated by best-fit straight-line-segments for use in the computer program. A by-product of the engraving test was the production of pre-engraved XM387 projectiles for use in subsequent testing of the firing fixture.

One of the listed parametric inputs is the number of gas ports used. This pertained to grenade ports and the option to vary the number was put in the program due to the uncertainty that was associated with the volume of gas that might be needed to successfully operate the mechanism. As it turned out, only one gas port was required. The last significant feature to be discussed on the input values was the value for gas efficiency. A math model for automatic weapon gas system was modified and tailored to the needs of the grenade system. The basic model is recorded in WECOM Technical Report No. RE TR-71-80, dated June 1971, author - Mr Curtis D. Johnson. The purpose of the gas model was to determine the gas flow and pressures seen at the base of the grenade projectile after the gas passed through the grenade gas tube. In basic terms, the grenade's actions are quite similar to that of a gas piston in a conventional gas system and was treated accordingly.

C. The Design:

The assembled firing fixture can be noted in US Army Weapons Command Drawing No. 71D21503; Appendix F. The drawing shows only the launcher assembled to a modified M16 barrel. For purposes of testing, this assembly was then in turn assembled to a standard M16 Rifle receiver. The launcher was positioned on the M16 Rifle so that the launcher did not interfer with the original shape of the M16 gas tube. This dictated that the M16 be layed on its side; so to speak. However, it was positioned such that the ejection port was facing upward when the launcher was in the firing position. This facilitated filming of the M16 ejection port. It should be noted that there is only one moving part on the launcher and that is the barrel.

In drawing number 71D21508, a standard M16 Rifle barrel was modified as shown. Also depicted are several changes that were made to the barrel as testing proceeded. The first was to move the .093 + .001 diameter grenade gas port 2 inches closer to the rifle chamber. The other major change was to machine a .166 + .001 long by .093 wide slot in the existing grenade gas port. Both modifications were performed to increase the grenade gas pressure.

The 40mm grenade barrel is shown in drawing number 71D21509. It was modified from an existing aluminum 40mm barrel. But due to a lack of original material on the grenade barrel, a steel sleeve (no. 71D21512) was required to provide a sufficient threading

surface. The outside of the sleeve had punch marks on it to assist in adjusting the initial volume of the launcher. This was performed by merely screwing the sleeve either in or out depending upon a predetermined volume requirement. This was determined by knowing the pitch of the thread and the area of the chamber. Loading the launcher was performed by fully unscrewing the barrel and inserting a grenade projectile (Figure 5). Minimum initial free volume was achieved by turning the loaded barrel in until the projectile base contacted the breech insert; No. 71D21505. The insert was contoured to fit the projectile's base to assist in obtaining minimum free volume. The insert also had provisions for accepting "O" ring seals. The seals were used in the initial testing to determine the effects of obturation. However, during a major bulk of the testing, the outer ring was removed but the inner one retained. No detrimental effects could be observed for this condition.

Part No. 71D21510 was used to seal off unused gas ports. During the course of the testing, sometimes it was desired that either the M16 or grenade port be sealed off. This is when the part was used.

D. The Test:

In conjunction with basic testing of the concept for determination of feasibility, several other side line activities developed. One such effort was that dealing with the effects due to engraving. As the test records will show, three basic projectile configurations were considered; no rotating bands, pre-engraved, and standard unengraved projectile. They were tested in the listed order so as to work up to the worst-case condition. This precaution was taken even in light of the initial analysis which indicated the system was safe. At the lower pressures and velocities, there was a marked difference in performance between the pre-engraved and standard. But, as the pressures and velocities approached levels which were consistent with other standard grenade systems, the difference between the two types of projectiles decreased to a low value. In fact, to reduce the frictional and engraving forces to a minimum, fired projectiles were caught in a barrel of rags just beyond the velocity coils and were then in turn used over again.

A secondary study undertaken during the course of the testing was obturation of the projectile. There were eight basic configurations; standard and pre-engraved projectiles, with an "O" ring, with grease, and with a plastic dip. The "O" ring was obtained from the high velocity 40mm grenade projectile which is used for waterproofing. The greased rounds used a silicone, high temperature grease which

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was rubbed around and in the rotating bands. The plastic coated rounds were dipped repeatedly in a liquid urethane to build up a coating. This was done to reduce the clearance between the rotating bands and the rifling grooves. The test results in Appendix C show that of the various methods of sealing, the urethane dipped projectiles performed the worst. The performance between the grease and the "O" ring were comparable. Additionally, the two just mentioned obturation methods gave improved results over the standard condition. However, the last few rounds that demonstrated feasibility were shot without the aid of obturation devices. It was one objective of the test to prove feasibility without the aid of other costly features or devices.

To back up the instrumentation, the testing was also filmed at 3500 frames per second. The qualitative nature of the obturation effects were correspondingly recorded. Additionally, a 40mm, M79 Grenade Launcher was filmed in a like manner. The lack of obturation on it was quite surprising. This was evidenced by the quantity of propellant gases blown by and preceding the projectile.

One of the requirements of the test was to record the muzzle velocity of both the rifle and grenade on each shot. To do this, special instrumentation used for recording machine gun velocities was required. This allowed for recording the muzzle velocities of both projectiles for each shot. Two sets of velocity screens were used with this equipment. Firing records for initial portion

of the test can be noted in Appendix D.

Selecting round number 149 from Appendix C as a sample round, pressure/time curves can be seen in Figure 8. The top curve is for the gas pressure measured in the M16 barrel directly over the grenade chamber pressure. The calibration of the top is 10,000 psi/cm on the vertical scale and 0.5 milliseconds/cm on the horizontal. The grid pattern are one cm squares. The lower curve calibration is 500 psi/cm on the vertical and 0.5 milliseconds/cm on the horizontal. The peak values are approximately 18,000 psi for the rifle bore pressure and 1900 psi for the grenade. These pressures produced a rifle muzzle velocity of 2928 fps and a grenade velocity of 225 fps. A standard projectile was used with 0.188 in^3 free volume. The previously described slotted gas port was used in conjunction with a .166 diameter grenade gas tube.

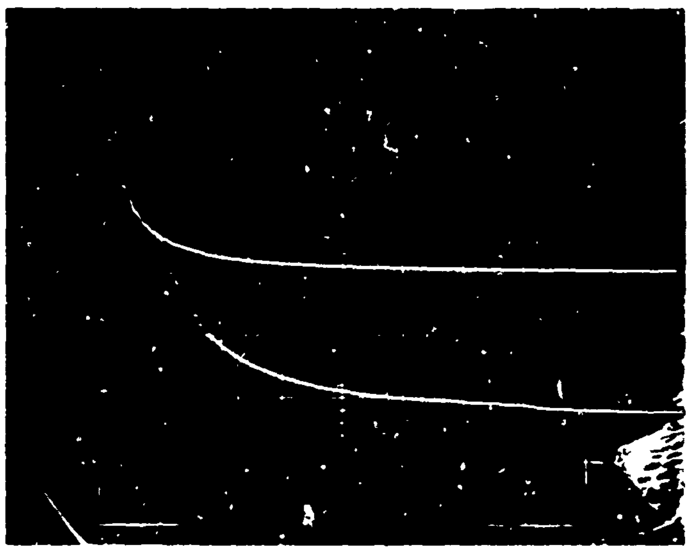

Figure 8: Pressure/Time Curves for Rifle Barrel and Launcher Chamber

APPENDIX A

```
C
C
C     ******************************************************************
C     *                                                                *
C     *   FEASIBILITY STUDY OF GRENADE LAUNCHER CONCEPT FOR R. DUNCAN  *
C     *                                                                *
C     ******************************************************************
C
C
      COMMON/RINPT/TMIN,TMAX,DTP,P(100),XCNG(50),FCNG(50),RTP,RTA,
     1              TK(12),TPRATM(12),TYMAX(12),DT,DTMIN,DXMAX,EPS,
     2              DTPRNT,BLI,DLNCH,VOLI,PORTD,XOI,WGREN,RK,EFF,STRTF,
     3              TMAXC,GAMMA
      COMMON/RCALC/BLTH,DPORT,YMAX,YSLOPE,PRATM,PL1,RT,GMASS,ALNCH,VOL,
     1              WGAS,FF1,PB1,DTSV,WEST,RTEST
      COMMON/XKINET/X,V,A,RES,TIMP,T
      COMMON/INPT/NPRES,NFRIC,NTAB,ITMAX,NPORTS,ISTART
      COMMON/ICALC/IT,LINES
      EXTERNAL PRESB,PRESL,FRIC
      IOUT=6
      G=32.2
      PI=3.141593
 1000 READ(5,900,END=10) ICNTRL
      GO TO(1,2,3,4,5,6),ICNTRL
C
C     READ PRESSURE DATA
C
    1 READ(5,901) NPRES,TMIN,TMAX,DTP
      READ(5,902) (P(J),J=1,NPRES)
      DO 11 J=1,NPRES
      P(J)=P(J)+14.7
   11 CONTINUE
      GO TO 1000
C
C     READ FRICTION DATA
C
    2 READ(5,900) NFRIC
      READ(5,902) (XCNG(J),J=1,NFRIC)
      READ(5,902) (FCNG(J),J=1,NFRIC)
      DO 21 J=1,NFRIC
      XCNG(J)=XCNG(J)/12.
   21 CONTINUE
      GO TO 1000
C
C     READ GAS DATA
C
    3 READ(5,901) NTAB,RTP,RTA,GAMMA
      READ(5,903) (TK(J),TPRATM(J),TYMAX(J),J=1,NTAB)
      GO TO 1000
C
C     READ NUMERIC DATA
C
    4 READ(5,901) ITMAX,DT,DTMIN,DXMAX,EPS,DTPRNT,TMAXC
      DXMAX=DXMAX/12.
      DTSVE=DT
      GO TO 1000
C
C     READ GUN DATA
C
    5 READ(5,902) BLI,DLNCH,VOLI,PORTD,XOI,WGREN,RK,EFF
      READ(5,900) NPORTS,ISTART
```

```
      BLTH=BLI/12.
      XO=XOI/12.
C
C     CALCULATE DIAMETER OF EQUIVALENT SINGLE PORT
C
      DPORT=PORTD*SQRT(FLOAT(NPORTS))
      IF(ISTART.EQ.0) GO TO 51
      READ(5,902) STRTF
      GO TO 1000
   51 STRTF=FRIC(XO)
      GO TO 1000
    6 DT=DTSVE
      CALL YPARM(YMAX,YSLOPE,PRATM,RK,TK,TPRATM,TYMAX.NTAB,12,IER)
      CALL HEAD(IOUT)
      LINES=56
      IT=0
      A=0.
      V=0.
      X=XO
      PL1=14.7
      TIMP=0.
      RES=0.
      RT=RTA
      GMASS=WGREN/G
      T=TMIN
      ALNCH=(PI/4.)*((DLNCH/25.4)**2)
      VOL=VOLI
      WGAS=VOLI*(0.075/1728.)
      FF1=STRTF
      PB1=PRESB(TMIN)
      CALL PRINT(IOUT)
      IF(FF1.NE.0.) CALL START(IOUT,PRESB,PRESL)
      DT=DTSVE
      CALL SHOOT(IOUT,PRESB,PRESL,FRIC)
      GO TO 1000
  900 FORMAT(2I5)
  901 FORMAT(I10,7F10.0)
  902 FORMAT(8F10.0)
  903 FORMAT(15F5.0)
   10 STOP
      END
C
C
C
      SUBROUTINE START(IOUT,PRESB,PRESL)
      COMMON/RINPT/TMIN,TMAX,DTP,P(100),XCNG(50),FCNG(50),RTP,RTA,
     1             TK(12),TPRATM(12),TYMAX(12),DT,DTMIN,DXMAX,EPS,
     2             DTPRNT,BLI,DLNCH,VOLI,PORTD,XOI,WGREN,RK,EFF,STRTF,
     3             TMAXC,GAMMA
      COMMON/RCALC/BLTH,DPORT,YMAX,YSLOPE,PRATM,PL1,RT,GMASS,ALNCH,VOL,
     1             WGAS,FF1,PB1,  SV,WEST,RTEST
      COMMON/XKINET/X,V,A,RES,  ar,T
      COMMON/ICALC/IT,LINES
      PLMIN=(FF1/ALNCH)+14.7
      IT=0
      TLPRNT=T
    5 IT=IT+1
      TT=T+DT
      PB2=PRESB(TT)
      PBAV=(PB1+PB2)/2.
      PL2=PRESL(0.,PBAV,PL1)
```

```
      PDIF=PL2-PLMIN
      IF(PDIF.GT.0.) GO TO 20
   10 WGAS=WEST
      T=TT
      PB1=PB2
      PL1=PL2
      RT=RTEST
      IF((((T-TLPRNT)/DTPRNT).LE.0.99).AND.(PDIF.LT.0.)) GO TO 15
      CALL PRINT(IOUT)
      TLPRNT=T
   15 IF(PDIF.EQ.0.) RETURN
      IF(T.GE.TMAX) GO TO 30
      IT=0
      GO TO 5
   20 IF((PDIF/PLMIN).GT.EPS) GO TO 25
      PDIF=0.
      GO TO 10
   25 DT=DT/2.
      GO TO 5
   30 WRITE(IOUT,930) X,T
      RETURN
  930 FORMAT('0',//,5X,'***** PROJECTILE STUCK IN BORE AT X = ',F10.7,
     1        ' FT, T = ',F10.7,' SEC *****')
      END
C
C
C
      SUBROUTINE SHOOT(IOUT,PRESB,PRESL,FRIC)
      COMMON/RINPT/TMIN,TMAX,DTP,P(100),XCNG(50),FCNG(50),RTP,RTA,
     1              TK(12),TPRATM(12),TYMAX(12),DT,DTMIN,DXMAX,EPS,
     2              DTPRNT,BLI,DLNCH,VOLI,PORTD,XOI,WGREN,RK,EFF,STRTF,
     3              TMAXC,GAMMA
      COMMON/RCALC/BLTH,DPORT,YMAX,YSLOPE,PRATM,PL1,RT,GMASS,ALNCH,VOL,
     1              WGAS,FF1,PB1,DTSV,WEST,RTEST
      COMMON/XKINET/X,V,A,RES,TIMP,T
      COMMON/INPT/NPRES,NFRIC,NTAB,ITMAX,NPORTS,ISTART
      COMMON/ICALC/IT,LINES
      TLPRNT=T
      DTCK=2.*DTMIN
      FF1=FRIC(X)
   10 IT=0
      DXEST=V*DT+(A/2.)*DT**2
   11 IT=IT+1
      IF((DXMAX.GE.DXEST).OR.(DT.LT.DTCK)) GO TO 20
      DT=DT/2.
      DXEST=DXEST/2.
   20 TEST=T+DT
      XEST=X+DXEST
      PB2=PRESB(TEST)
      PBAV=(PB1+PB2)/2.
      FF2=FRIC(XEST)
      FAV=(FF1+FF2)/2.
      PL2=PRESL(DXEST,PBAV,PL1)
      FPAV=ALNCH*(0.5*(PL1+PL2)-14.7)
      CALL DYNAM(ACK,VCK,XCK,RES,DIMP,FAV,FPAV,V,X,DT,GMASS)
      DXCK=XCK-X
      IF((0.005*ABS(DXEST-DXCK)).GE.(EPS*DT)) GO TO 50
      T=TEST
      V=VCK
      A=ACK
      X=XCK
```

```
      PB1=PB2
      FF1=FF2
      PL1=PL2
      VOL=VOLI+(ALNCH*(X-XOI))
      TIMP=TIMP+DIMP
      WGAS=WEST
      RT=RTEST
      IF((((T-TLPRNT)/DTPRNT).LT.0.99).AND.(X.LT.BLTH)) GO TO 10
      CALL PRINT(IOUT)
      TLPRNT=T
      IF(X.GE.BLTH) RETURN
      IF(V.LT.0.) GO TO 70
      IF(T.GE.TMAXC) GO TO 80
      GO TO 10
   50 IF(IT.GE.ITMAX) GO TO 60
      DXEST=DXCK
      GO TO 11
   60 WRITE(IOUT,925) X,T,IT
   70 WRITE(IOUT,930) X,T
      RETURN
   80 WRITE(IOUT,935)
      RETURN
  925 FORMAT('1',////,5X,'FAILURE TO CONVERGE AT X = ',F10.7,' FT, T = '
     1,F10.7,' SEC IN ',I4,' ITERATIONS*****EXECUTION TERMINATED')
  930 FORMAT('0',//,5X,'***** PROJECTILE STUCK IN BORE AT X = ',F10.7,
     1       ' FT, T = ',F10.7,' SEC *****')
  935 FORMAT('0',//,5X,'***** MAXIMUM CALCULATION TIME EXCEEDED *****')
      END
C
C
C
      FUNCTION PRESB(T)
      COMMON/RINPT/TMIN,TMAX,DTP,P(100),XCNG(50),FCNG(50),RTP,RTA,
     1             TK(12),TPRATM(12),TYMAX(12),DT,DTMIN,DXMAX,EPS,
     2             DTPRNT,BLI,DLNCH,VOLI,PORTD,XOI,WGREN,RK,EFF,STRTF,
     3             TMAXC,GAMMA
      COMMON/INPT/NPRES,NFRIC,NTAB,ITMAX,NPORTS,ISTART
      PRESB=14.7
      IF((T.GT.TMAX).OR.(T.LT.TMIN)) RETURN
      JT2=INT((T-TMIN)/DTP)+1
      IU=JT2+1
      PL=P(JT2)
      PRESB=PL+(((P(IU)-PL)/DTP)*(T-TMIN-(DTP*FLOAT(JT2-1))))
      RETURN
      END
C
C
C
      FUNCTION PRESL(DXEST,PBORE,PLI)
      COMMON/RINPT/TMIN,TMAX,DTP,P(100),XCNG(50),FCNG(50),RTP,RTA,
     1             TK(12),TPRATM(12),TYMAX(12),DT,DTMIN,DXMAX,EPS,
     2             DTPRNT,BLI,DLNCH,VOLI,PORTD,XOI,WGREN,RK,EFF,STRTF,
     3             TMAXC,GAMMA
      COMMON/RCALC/BLTH,DPORT,YMAX,YSLOPE,PRATM,PL1,RT,GMASS,ALNCH,VOL,
     1             WGAS,FF1,PB1,DTSV,WEST,RTEST
      PDIF=PBORE-PLI
      APDIF=ABS(PDIF)
      PRAT=APDIF/AMAX1(PBORE,PLI)
      IF(PRAT.LT.PRATM) GO TO 20
      Y=YMAX
      GO TO 30
```

```
   20 Y=1.+YSLOPE*PRAT
   30 VOLAV=VOL+((ALNCH*DXEST)/2.)
C     IF(PDIF.LT.0.) GO TO 35                                          *
      IF(PDIF.LT.0.) GO TO 35
C     VSP=RTP/(144.*PBORE)                                             *
      VSP=RTP/(144.*PBORE)
C     GO TO 37                                                         *
      GO TO 37
C  35 VSP=VOL/(1728.*WGAS)                                             *
   35 VSP=VOL/(1728.*WGAS)
   37 W=0.525*Y*(DPORT**2)*SQRT(APDIF/(RK*VSP))*DT
      IF(PDIF.LT.0.) W=-W
   50 EFFW=EFF*W
      WEST=WGAS+EFFW
      VOLEST=VOLAV+((ALNCH*DXEST)/2.)
      RTEST=(RT*WGAS+RTP*EFFW)/WEST
C     PRESL=PLI*(((WEST*VOL)/(WGAS*VOLEST))**GAMMA)                    *
      PRESL=PLI*(((WEST*VOL)/(WGAS*VOLEST))**GAMMA)
      RETURN
      END
C
C
C
      FUNCTION FRIC(X)
      COMMON/RINPT/TMIN,TMAX,DTP,P(100),XCNG(50),FCNG(50),RTP,RTA,
     1             TK(12),TPRATM(12),TYMAX(12),DT,DTMIN,DXMAX,EPS,
     2             DTPRNT,BLI,DLNCH,VOLI,PORTD,XOI,WGREN,RK,EFF,STRTF,
     3             TMAXC,GAMMA
      COMMON/RCALC/BLTH,DPORT,YMAX,YSLOPE,PRATM,PL1,RT,GMASS,ALNCH,VOL,
     1             WGAS,FF1,PB1,DTSV,WEST,RTEST
      COMMON/INPT/NPRES,NFRIC,NTAB,ITMAX,NPORTS,ISTART
      FRIC=0.
      IF((X.GT.BLTH).OR.(X.LT.0.)) RETURN
      DO 5 K=2,NFRIC
      JF2=K-1
      IF(XCNG(K).GE.X) GO TO 10
    5 CONTINUE
   10 IU=JF2+1
      FL=FCNG(JF2)
      XL=XCNG(JF2)
      FRIC=FL+(((FCNG(IU)-FL)/(XCNG(IU)-XL))*(X-XL))
      RETURN
      END
C
C
C
      SUBROUTINE DYNAM(AC,VEL,POS,RES,DIMP,FAV,FPAV,V,X,DT,GMASS)
      RES=FPAV-FAV
      IF((RES.LE.0.).AND.(V.LE.0.)) RES=0.
      AC=RES/GMASS
      VEL=V+(AC*DT)
      POS=(AC/2.)*(DT**2)+(V*DT)+X
      DIMP=RES*DT
      RETURN
      END
C
C
C
      SUBROUTINE YPARM(YMAX,YSLOPE,PRATM,RK,TK,TPRATM,TYMAX,NTAB,NM,IER)
      DIMENSION TK(NM),TPRATM(NM),TYMAX(NM)
      IER=-1
```

```
      IF((RK.GE.TK(1)).AND.(RK.LE.TK(NTAB))) GO TO 5
      WRITE(6,900) RK
  900 FORMAT('0',T5,'RK = ',T10,F6.2,T18,'; THIS VALUE IS OUTSIDE THE RA
     1NGE OF THE TABLE')
      RETURN
    5 DO 10 K=2,NTAB
      KUP=K
      IF(TK(K).GE.RK) GO TO 15
   10 CONTINUE
   15 KL=KUP-1
      TKL=TK(KL)
      POR=(RK-TKL)/(TK(KUP)-TKL)
      PL=TPRATM(KUP-1)
      PRATM=PL+(POR*(TPRATM(KUP)-PL))
      YL=TYMAX(KL)
      YMAX=YL+(POR*(TYMAX(KUP)-YL))
      YSLOPE=(YMAX-1.)/PRATM
      IER=0
      RETURN
      END
C
C
C
      SUBROUTINE HEAD(IOUT)
      COMMON/RINPT/TMIN,TMAX,DTP,P(100),XCNG(50),FCNG(50),RTP,RTA,
     1             TK(12),TPRATM(12),TYMAX(12),DT,DTMIN,DXMAX,EPS,
     2             DTPRNT,BLI,DLNCH,VOLI,PORTD,XOI,WGREN,RK,EFF,STRTF,
     3             TMAXC,GAMMA
      COMMON/RCALC/BLTH,DPORT,YMAX,YSLOPE,PRATM,PL1,RT,GMASS,ALNCH,VOL,
     1             WGAS,FF1,PB1,DTSV,WEST,RTEST
      COMMON/INPT/NPRES,NFRIC,NTAB,ITMAX,NPORTS,ISTART
      WRITE(IOUT,900)
      WRITE(IOUT,901) NPRES,TMIN,TMAX,DTP
      WRITE(IOUT,902) (P(J),J=1,NPRES)
      WRITE(IOUT,903) NFRIC
      WRITE(IOUT,904) (XCNG(J),FCNG(J),J=1,NFRIC)
      WRITE(IOUT,905) RTP,RTA,YMAX,YSLOPE,PRATM,NTAB
      WRITE(IOUT,906) (TK(J),TPRATM(J),TYMAX(J),J=1,NTAB)
      WRITE(IOUT,907) DT,DTMIN,DTPRNT,DXMAX,EPS,ITMAX,TMAXC
      WRITE(IOUT,908) BLI,WGREN,DLNCH,RK,VOLI,EFF,PORTD,ISTART,NPORTS,
     1                STRTF,XOI
  900 FORMAT('1',//,T32,'**************************************************
     1*******************',/,T32,'*',T98,'*',/,T32,'*   FEASIBILITY STU
     2DY OF GRENADE LAUNCHER CONCEPT FOR R. DUNCAN   *',/,T32,'*',T98,'*
     3',/,T32,'*************************************************************
     4***********',///)
  901 FORMAT('0',T60,'PRESSURE DATA',//,T10,'NPRES = ',T18,I3,T30,'TMIN
     1= ',T37,F10.8,T48,'SEC',T60,'TMAX = ',T67,F10.8,T78,'SEC',T90,'DTP
     2 = ',T96,F10.8,T107,'SEC',//,T52,'RIFLE BORE PRESSURE (PSIA)',/)
  902 FORMAT('0',5X,8F15.1)
  903 FORMAT('0',//,T54,'FRICTION DATA',//,T55,'NFRIC = ',T63,I2,//,T19,
     1'FT',T28,'LB',T39,'FT',T48,'LB',T59,'FT',T68,'LB',T79,'FT',T88,'LB
     2',T99,'FT',T108,'LB',/)
  904 FORMAT('0',T15,F7.4,T25,F7.2,T35,F7.4,T45,F7.2,T55,F7.4,T65,F7.2,
     1T75,F7.4,T85,F7.2,T95,F7.4,T105,F7.2)
  905 FORMAT('0',//,T57,'GAS DATA',//,T15,'RTP = ',T21,F8.1,T35,'RTA = '
     1,T41,F7.1,T54,'YMAX = ',T61,F5.3,T72,'YSLOPE = ',T81,F6.3,T92,'PRA
     2TM = ',T100,F5.3,//,T60,'NTAB = ',T67,I3,//,T9,'TK',T17,'TPRATM',
     3T27,'TYMAX',T39,'TK',T47,'TPRATM',T57,'TYMAX',T69,'TK',T77,'TPRATM
     4',T87,'TYMAX',T99,'TK',T107,'TPRATM',T117,'TYMAX',//)
  906 FORMAT('0',T7,F6.1,T17,F6.3,T27,F6.3,T37,F6.1,T47,F6.3,T57,F6.3,
```

```
   1T67,F6.1,T77,F6.3,T87,F6.3,T97,F6.1,T107,F6.3,T117,F6.3)
907 FORMAT('0',//,T59,'NUMERIC DATA',//,T2,'DT = ',T6,F10.8,T17,'SEC',
   1T23,'DTMIN = ',T31,F10.8,T42,'SEC',T49,'DTPRNT = ',T58,F10.8,T69,
   2'SEC',T76,'DXMAX = ',T84,F10.8,T95,'FT',T101,'EPS = ',T107,F10.8,
   3T120,'ITMAX = ',T128,I4,//,T50,'TMAXC = ',T58,F10.8,T69,'SEC')
908 FORMAT('0',//,T61,'GUN DATA',//,T20,'BARREL LENGTH = ',T36,F5.2,
   1T42,'IN',T75,'GRENADE WT = ',T88,F5.3,T94,'LB',//,T20,'BORE DIAMET
   2ER = ',T36,F5.2,T42,'MM',T75,'RESISTANCE COEFFICIENT = ',T100,F5.1
   3,//,T20,'CHAMBER VOLUME = ',T37,F5.3,T43,'CU.IN',T75,'EFFICIENCY =
   4 ',T88,F5.3,//,T20,'PORT DIAMETER = ',T36,F5.3,T42,'IN',T75,'ISTAR
   5T = ',T84,I1,//,T20,'NUMBER OF PORTS = ',T38,I1,T75,'SHOT START FO
   6RCE = ',T94,F5.1,T100,'LB',//,T20,'INITIAL GRENADE POSITION = ',
   7T47,F6.3,T54,'IN')
    RETURN
    END
C
C
C
    SUBROUTINE PRINT(IOUT)
    COMMON/RCALC/BLTH,DPORT,YMAX,YSLOPE,PRATM,PL1,RT,GMASS,ALNCH,VOL,
   1            WGAS,FF1,PB1,DTSV,WEST,RTEST
    COMMON/XKINET/X,V,A,RES,TIMP,T
    COMMON/ICALC/IT,LINES
    TWRITE=1000.*T
    XWRITE=12.*X
    IF(LINES.LE.55) GO TO 45
    WRITE(IOUT,915)
    LINES=0
 45 WRITE(IOUT,920) TWRITE,XWRITE,V,PL1,PB1,FF1,RES,TIMP,RT,IT
    LINES=LINES+1
915 FORMAT('1',T4,'TIME',T12,'POSITION',T24,'VELOCITY',T37,'LAUNCHER',
   1T51,'RIFLE PRES.',T66,'MAX. FRIC.',T82,'RESULTANT',T95,'NET IMPULS
   2E',T109,'LAUNCHER RT',T126,'ITER',/,T3,'(MSEC)',T14,'(IN)',T25,'(F
   3PS)',T35,'PRES. (PSIA)',T53,'(PSIA)',T66,'FORCE (LB)',T82,'FORCE (
   4LB)',T96,'(LB-SEC)',T109,'(FT-LB/LB)',//)
920 FORMAT(' ',T2,F7.4,T11,F8.4,T24,F8.3,T37,F8.2,T52,F9.2,T66,F8.2,
   1T82,F9.2,T96,F8.4,T110,F9.1,T126,I3)
    RETURN
    END
```

APPENDIX B

APPENDIX B

TEST PROGRAM REQUEST

1. Material to be tested: Grenade Launching Firing Fixture, Drawing No. 71D21503.

2. TPR-SAL-71-I-021

3. Project Authority: DA Project No. 1W562604A621-01

4. Expenditure Order Number: 553103

5. Test Installation: Test and Evaluation Branch, Rock Island Arsenal

6. Objectives:

a. To determine feasibility of using propellant gases bled from point fire bore to launch grenades from a separate barrel.

b. To determine the effect of launcher on mechanical functioning of M16A1 Rifle.

c. To determine rifle bore pressure at launcher gas port, and to determine velocity of rifle projectiles when launching grenades.

d. To determine grenade launcher chamber pressures and to determine velocity of grenades.

e. To determine recoil and noise levels of system when launching grenades.

7. Material for Test:

a. Grenade Launching Firing Fixture Drawing No. 71D21503

b. 40mm, XM387; 10 rounds

c. 5.56mm, M193; 58 rounds

d. 40mm inert projectiles pulled from XM387, 38 rounds

e. lumaline screens

f. chronograph

g. photographic equipment

h. pressure measuring equipment

i. depth micrometer 3-4 inch

j. decibel level recording equipment

k. recoil level recording equipment

l. one M79 Grenade Launcher; one M16A1 Rifle; one M16A1 Rifle with M203 Grenade Launcher.

8. Description of Test:

a. Test set-up 8.(2)(a), (b) and (c) will be photographed and subsequent set-ups as designated by the test engineer. This will include still photographs plus high speed movies. High speed movies will be made on grenade firing only.

b. Velocity records will be made of each projectile fired except where noted.

c. Pressure-time curves will be recorded for all firings except where noted.

d. All firings will be performed in semi-automatic mode.

e. Firing schedule: (To be performed in the sequence noted below)

(1) Launcher Comparison Subtest:

(a) Use one M79 Grenade Launcher, one M16A1 Rifle with M203 Grenade Launcher, and one M16A1 Rifle.

(b) Fire five rounds of XM387, 40mm ammunition through both the M79 and the M16/M203. Fire five rounds of M193, 5.56mm ammunition through the M16A1 Rifle.

(c) Measure the recoil force at the butt plates, noise, and muzzle velocity of each round.

(2) Initial Check Test:

(a) Rifle gas port closed. Grenade gas port closed.

1. Grenade launcher removed from rifle. Rifle bore sighted.

2. Fire five rounds. Measure pressure at grenade gas port on all five rounds. Measure noise and velocity of first and second rounds only. Retain target.

(b) Rifle gas tube connected to rifle. Grenade Launcher removed from rifle.

1. Grenade launcher gas port closed. Rifle bore sighted.

2. Fire five rounds. Measure pressure on launcher gas port on all five rounds. Measure noise recoil and velocity on first and second rounds only. Retain target. Observe functioning of rifle mechanism.

(c) Rifle gas tube connected to rifle. Grenade launcher attached to rifle.

1. Grenade launcher port open. Rifle bore signted.

2. Fire five rounds of M193 ammunition. Measure pressure at launcher gas port on all five rounds. Measure noise, recoil, and velocity on first and second rounds only. Retain target. Observe function of rifle mechanism.

(3) <u>Soft Catch Projectile Subtest</u>:

NOTE: Rifle Gas Tube and Grenade Launcher Assembled to M16 Rifle.

(a) Load <u>modified</u> 40mm projectile with front of projectile flush with muzzle of grenade launcher barrel. Fire one round. Measure pressures at launcher gas port end chamber. Also measure noise, recoil, and muzzle velocities of both the grenade and 5.56mm bullet.

(b) Load <u>modified</u> 40mm projectile with base of projectile seated against receiver insert. Fire one round. Measure pressure at launcher port and chamber. Also measure noise, recoil, and muzzle velocities of both the grenade and the 5.56mm bullet.

(4) <u>Launcher Variable Volume Subtest</u>:

(a) Gas Tube and launcher attached to M16.

1. Load grenade launcher barrel drawing no. 71D21509

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NOTE: Loading sequence for grenade launcher barrel.

a. Hold grenade launcher barrel horizontal, insert grenade into chamber and into contact with rifling. Use no force.

b. Screw barrel into receiver dwg no. 71D21504 until grenade bottoms against receiver insert drawing no. 71D21505. Do not force.

c. Withdraw (unscrew) grenade launcher barrel ten full turns to give .625 inches linear component of chamber volume.

2. Fire four rounds.

3. Measure pressure at launcher gas port and chamber on all rounds.

4. Measure muzzle velocities of both the grenade and bullet on all rounds.

5. Measure recoil and noise on first two rounds.

6. Record performance of M16 Rifle.

(b) Repeat (4)(a) above except as noted below:

1. Withdraw (unscrew) grenade launcher barrel eight full turns to give .500 inches linear component of chamber volume.

2. Fire two rounds.

(c) Repeat (4)(a) above except as noted below:

1. Withdraw (unscrew) grenade launcher barrel six full turns to give .375 inches linear component of chamber volume.

2. Fire two rounds.

(d) Repeat (4)(a) above except as noted below:

1. Withdraw (unscrew) grenade launcher barrel four full turns to give .250 inches linear component of chamber volume.

2. Fire two rounds.

(e) Repeat (4)(a) above except as noted below:

1. Withdraw (unscrew) grenade launcher barrel two full turns to give .125 inches linear component of chamber volume.

2. Fire two rounds.

(f) Repeat (4)(a) above except as noted below:

1. Withdraw (unscrew) barrel 1/4 turn to give .025 inches linear component of chamber volume.

2. Fire two rounds.

(g) Repeat the one test of (4)(a) thru (4)(f) which resulted in the highest grenade velocity, except in this test the rifle gas port is closed. Fire two rounds.

(5) Free Bore Subtest:

Load grenade into chamber and hold in contact with rifling. Do not use force. Measure distance from front of projectile to face of muzzle insert. Screw barrel into receiver until grenade contacts receiver insert. Do not use force. Set chamber volume to that selected in (4)(g) above.

(a) Withdraw (unscrew) the barrel two additional turns. Using the muzzle insert dwg no. 71C21588 and kepth micrometer, push grenade rearward .13 inches. Fire two rounds.

(b) Withdraw (unscrew) the barrel one additional turn. Using muzzle insert and depth micrometer, push grenade rearware .06 inch. Fire two rounds.

(c) Load grenade into chamber and hold in contact with rifling. Do not use force. Do not give grenade free bore. Fire two rounds.

(6) Variable Pre-Engraving Subtest:

Load grenade launcher barrel and screw into receiver until grenade contacts receiver insert.

(a) Screw barrel in one additional turn to achieve approximately .06 inch pre-engraving. Use hand pressure only. Set chamber volume to that selected in (4)(g) above. Fire two rounds.

(b) Screw barrel in two additional turns to achieve approximately .13 inches pre-engraving. Use hand pressure only. Set chamber volume to that selected in (4)(g) above. Fire two rounds.

(7) Final Configuration Subtest:

Select configuration which resulted in highest velocity to this point. Fire four additional rounds.

(a) Record noise and recoil levels.

(b) Measure muzzle velocities of grenade and 5.56mm bullet.

(c) Measure pressure at launcher port and chamber

(d) Record two shots on high speed movies (FASTEX)

(8) Effect of Obturation Subtest:

Use same configuration as in (7).

(a) On dwg 71D21503 remove O-ring, MS 28775-60 and ring, backer MS29774-127. Fire four additional rounds.

1. Measure velocities of grenade and 5.56mm bullet.

2. Measure pressure at launcher port and chamber.

3. Record two shots on high speed movies (FASTEX)

(b) On drawing 71D21503 remove all O-rings and backer rings. Fire four additional rounds.

1. Measure velocities of grenade and 5.56mm bullets.

2. Measure pressure at launcher port and chamber.

3. Record two shots on high speed movies (FASTEX)

9. Perform any other task determined necessary to achieve objective. Mr R. Duncan and.or Mr. G. Reynolds will be present at all testing.

10. Coordination: Testing will be coordinated with Mr R. Duncan, ext. 4661. The final report, test records, and films will be forwarded to us, SWERR-S-I.

APPENDIX C

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APPENDIX C

TEST RESULTS FROM THE GAS LAUNCHED GRENADE CONCEPT

RD NO.	PROJECTILES FIRED 5.56mm	40mm	GRENADE PROJECTILE CONDITION	GRENADE BARREL POSITION	MUZZLE VELOCITY, fps 40mm	5.56mm
1	M193	---	N/A	N/A	--	3197
2	"	---	"	"	--	3173
3	"	---	"	"	--	3199
4	"	---	"	"	--	3217
5	"	---	"	"	--	3197
6	"	---	"	"	--	3196
7	"	---	"	"	--	3215
8	"	---	"	"	--	3190
9	"	---	"	"	--	3189
10	"	---	"	"	--	3216
11	"	---	"	"	--	3219
12	"	---	"	"	--	3185
13	"	XM387	No rotating bands	Seated Flush	NR	NR
14	"	"	"	"	NR	3176
15	"	"	"	"	NR	3084
16	"	"	"	"	NR	3135
17	"	"	Pre-engraved	"	NR	3162
18	"	"	"	"	NR	3186
19	"	"	Standard	"	NR	3146
20	"	"	Pre-engraved	"	NR	3171
21	"	XM387	"	"	NR	3151
22	"	---	N/A	N/A	--	3149
23	"	---	"	"	--	NR
24	"	---	"	"	--	NR
25	"	---	"	"	--	NR
26	"	---	"	"	--	NR
27	"	---	"	"	--	NR
28	M193	---	N/A	N/A	--	NR
29	"	XM387	Pre-engraved	Seated Flush	NR	NR
30	"	"	"	"	103	3167
31	"	"	"	"	104	NR
32	"	"	"	"	101	3228
33	"	"	"	Backed Out 1 Turn	112	3215
34	"	"	"	Backed Out 2 Turns	105	3210
35	"	"	Standard	Backed Out 1 Turn	45	3189
36	"	"	"	"	53	3207
37	"	"	"	"	54	3223
38	"	"	"	"	67	3210
39	"	"	"	"	67	3244
Grenade gas port moved 2" closer to rifle chamber				"		
40	"	---	N/A	N/A	--	3134
41	"	---	"	"	--	3162
42	"	---	"	"	--	3187
43	"	XM387	Standard	Backed Out 1 Turn	110	NR

RD NO.	PROJECTILES FIRED 5.56mm	40mm	GRENADE PROJECTILE CONDITION	GRENADE BARREL POSITION	MUZZLE VELOCITY, fps 40mm	5.56 mm
44	M193	XM387	Standard	Backed Out 1 Turn	112	3172
45	"	"	"	"	115	3139
46	"	"	"	"	118	3095
47	"	"	"	"	114	3137
48	"	"	"	"	110	3174
49	"	"	"	"	111	NR
50	"	"	"	Backed Out 2 Turns	106	3207
51	"	"	"	"	116	3164
52	"	"	"	"	109	3129
53	"	"	"	Backed Out 1/2 Turn	NR	3137
54	"	"	"	"	116	3174
55	"	"	"	"	113	3184
56	"	---	N/A	N/A	--	NR
57	"	---	N/A	N/A	--	3207
58	"	XM387	Standard w/"O" Ring	Backed Out 1 Turn	NR	3127
59	"	---	N/A	N/A	--	3115
60	"	XM387	Standard w/"O" Ring	Backed Out 1 Turn	130	3184
61	"	"	"	"	NR	NR
62	"	"	"	"	135	3192
63	"	"	"	"	133	3170
64	"	"	Pre-engraved w/"O" Ring	"	141	3210
65	"	---	N/A	N/A	--	NR
66	"	---	"	"	--	3164
67	"	XM387	Pre-engraved w/"O" Ring	Backed Out 1 Turn	149	3160
68	"	"	"	"	148	3187
69	"	"	Standard w/grease	"	147	3210
70	"	"	"	"	156	3149
71	"	"	"	"	157	3160
72	"	"	Standard w/urethan dip	"	135	3172
73	"	---	N/A	N/A	--	3197
74	"	XM387	Standard w/urethan dip	Backed Out 1 Turn	138	3144
75	"	"	Standard	Backed Out 1/4 Turn	125	3189
76	"	"	"	"	125	3167
77	"	"	"	Backed Out 1/2 Turn	122	3165
78	"	"	"	"	128	3170
79	"	"	"	"	122	3190
80	M193	XM387	Standard w/eva dip	Backed Out 1 Turn	137	3134
81	"	"	"	"	138	3194
82	"	"	Pre-engraved w/"O" Ring	"	NR	NR
83	"	---	N/A	N/A	--	3132
84	"	---	"	"	--	NR
85	"	---	"	"	--	3187
86	"	---	"	"	--	3172
87	"	---	"	"	--	3189
88	"	---	"	"	--	3212
89	"	---	"	"	--	NR
90	"	---	"	"	--	3144
91	"	---	"	"	--	3142

RD NO.	PROJECTILES FIRED 5.56mm	40mm	GRENADE PROJECTILE CONDITION	GRENADE BARREL POSITION	MUZZLE VELOCITY, fps 40mm	5.56mm
92	M193	---	N/A	N/A	--	3164
93	"	XM387	Pre-engraved w/grease	Backed Out 1 Turn	170	NR
94	"	"	"	"	168	NR
95	"	"	Pre-engraved w/"O" Ring	"	169	NR
96	"	"	"	"	156	NR
97	"	"	Standard w/urethan dip	"	155	NR
98	"	"	"	"	154	NR
99	"	"	Pre-engraved w/urethan dip	"	NR	NR
100	"	"	Pre-engraved	Backed Out 1/4 Turn	NR	3021
101	"	"	"	"	NR	NR
102	"	"	"	"	211	NR
103	"	"	"	"	NR	3099
104	"	"	"	"	NR	3010
105	"	"	"	"	211	2983
106	"	"	"	"	210	2969
107	"	"	"	"	211	3001
108	"	"	"	"	206	3014
109	"	"	Standard	"	NR	3077
110	"	"	"	"	198	3065
111	"	"	"	"	202	2985
112	"	"	"	"	206	3023
113	"	"	Pre-engraved	Backed Out 1/8 Turn	208	3053
114	"	"	"	"	204	3079
115	"	"	"	Backed Out 1/16 Turn	203	3096
116	"	"	"	Backed Out 3/8 Turn	204	3101
117	"	"	"	"	NR	3070
118	"	"	"	Seated Flush	206	3077
119	"	"	Pre-engraved w/eva dip	Backed Out 1/4 Turn	208	3132
120	Blank	"	Pre-engraved	"	84	--
121	"	"	"	"	85	--
122	"	"	"	Backed Out 1/8 Turn	85	--
123	"	"	"	Backed Out 1/16 Turn	85	--
124	"	"	Pre-engraved w/eva dip	"	103	--
125	"	"	"	"	NR	--
126	"	"	"	"	65	--
127	"	"	Standard	Backed Out 1/4 Turn	NR	--
128	"	"	Pre-engraved	Seated Flush	NR	--
129	M193	"	"	Backed Out 1 Turn	NR	NR
130	"	"	"	"	NR	NR
131	"	"	"	"	NR	NR
132	"	"	"	"	NR	3075
133	"	--	"	"	NR	3055
134	"	--	N/A	N/A	--	3110
135	"	--	"	"	--	3007
136	"	XM387	Pre-engraved	Backed Out 1/4 Turn	218	3074
137	"	"	Pre-engraved w/eva dip	Backed Out 1/2 Turn	219	3081
138	"	"	Pre-engraved	Backed Out 3/4 Turn	211	3021
139	"	"	"	Backed Out 1/4 Turn	NR	NR
140	"	"	Standard	Backed Out 1 Turn	209	3016

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RD NO.	PROJECTILE FIRED 5.56mm	40mm	GRENADE PROJECTILE CONDITION	GRENADE BARREL POSITION	MUZZLE VELOCITY, fps 40mm	5.56mm
141	M193	XM387	Standard	Backed Out 1 1/2 Turn	205	3081
142	"	"	"	Backed Out 1/2 Turn	200	3084
143	"	"	Pre-engraved	Backed Out 1 Turn	200	3120
144	"	"	"	Backed Out 1/2 Turn	201	3058
145	"	"	"	Backed Out 1 Turn	231	2935
146	"	"	"	"	229	2930
147	"	"	Standard	"	222	2941
148	"	"	"	"	222	2956
149	"	"	"	"	225	2928
150	"	"	"	Backed Out 2 Turns	223	2902
151	"	"	"	"	224	2917
152	"	"	"	"	221	2943
153	"	"	Pre-engraved	Backed Out 1/2 Turn	225	2912
154	"	"	"	"	224	2921
155	"	"	"	"	221	2956
156	"	"	"	Backed Out 1/4 Turn	225	3000
157	"	"	"	"	221	2894
158	"	"	"	"	227	2900
159	"	"	"	Seat Flush	221	2998
160	"	"	"	"	213	3053
161	"	"	"	Backed Out 1 Turn	227	2932
162	"	"	"	"	223	2956
163	"	"	"	"	225	2904
164	"	"	"	"	229	2956

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APPENDIX D

SMALL ARMS TEST DATA RECORD

DATE	TIME	LOCATION	JOB NO.
17 Aug 71		#2	71-65

JOB TITLE: 40MM Gernade Launcher Test

T(°F)	RH(%)	P(InHg)

WEAPON TYPE	WEAPON SER NO.	AMMUNITION TYPE	AMMUNITION LOT NO.	FIXTURE TYPE	FIXTURE NO.
M16 with Launcher	800169	5.56mm Ball	RA 2-60	Functioning jack	RIA DA3784

ROUNDS LOADED	ROUNDS FIRED	ROUNDS TOTAL	TYPE OF FIRE	COMMENTS		Fastax Velocity 40mm	Velocity 5.56mm	Sound DB
1	1	1	SEMI	Rifle and Gernade Gasport Closed		-	3197	153
1	1	2	"	" " " " "		-	3173	156.3
1	1	3	"	" " " " "		-	3199	157.5
1	1	4	"	" " " " "		-	3217	157.0
1	1	5	"	" " " " "		-	3197	157.5
1	1	6	"	" " " " "		-	3196	157.0
1	1	7	"	" " " " "		-	3215	158.0
1	1	8	"	Gas Tube Connected Gernade Launcher Removed FX		-	3190	156.5
1	1	9	"	" " " " " " FX		-	3189	158.0
1	1	10	"	" " " " " " FX	#1	-	3216	157.5
1	1	11	"	" " " " " " FX	#2	-	3219	156.0
				Above FX's caused by misaligned gasport?	--	-	--	-----
1	1	12	SEMI	Gas Tube and Launcher installed FX	--	-	3185	-----
1	1	13	"	" " " " " "	#3	-	--	156.0
				18 Aug 71				
1	1	14	SEMI	Gas Tube Launcher Installed Machined 40mmrd FX	#4	907?	3176	160
1	1	15	"	" " " " " " FX	#5	206	3084	156.5
1	1	16	"	" " " " " " FX	#6	197	3135	157.0
				" " " " Pre-Engraved 40mm rd				
1	1	17	"	Fastax Camera moved to pickup projectile flight FX	#7	198	3162	155.5
1	1	18	"	Same as Rd 17. FX	#8	197	3186	157.0
1	1	19	"	Same as RD 17 But with std projectile FX didn't clear bore	#9	208?	3146	160.0

TEST CONDUCTED BY: Terrell, Rokemeyer

AMSWE Form 454, 20 Oct 69

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SMALL ARMS TEST DATA RECORD

DATE: 18 Aug 71 | TIME: | LOCATION: #2 | JOB NO.: 71-65

JOB TITLE: 40MM Gernade Launcher Test | T(°F): | RH(%): | P(InHg):

WEAPON — TYPE: M16A1 W/Launcher | SER NO.: 800169

AMMUNITION — TYPE: 5.56 Ball | LOT NO.: RA2-60

FIXTURE — TYPE: Functioning Jack | NO.: RIA DA 3784

ROUNDS LOADED	ROUNDS FIRED	ROUNDS TOTAL	TYPE OF FIRE	COMMENTS	Fastax	Velocity MM	Velocity 5.56	Sound DB
1	1	20	Semi	Same as RD 17 No Fastax	—	156	3171	156.0
1	1	21	"	Same as RD 17 No Fastax	—	157	3151	156.0
1	1	22	"	5.56MM only velocity check	—	—	3149	—
1	1	23	"	" " " "	—	—	—	—
5	5	28	"	" " " " OK	—	—	—	—
—	—	—	—	M79 #71835 Lot# MA34-9 4rds for velocity check	—	—	—	—
1	1	29	Semi	Pre-engraved Projectile	—	—	—	—
1	1	30	"	" " "	—	103	3167	—
1	1	31	"	" " "	—	—	—	—
1	1	32	"	" " "	—	101.7	3228	—
1	1	33	"	" " " BBL 1 Turn Out	#10	112.2	3215	—
1	1	34	"	" " " BBL 2 Turns Out	#11	105.2	3210	—
1	1	35	"	STD Projectile BBL 1 Turn Out	#12	ϕ45.2	3189	—
1	1	36	"	STD Projectile "O" Rings Removed BBL 1 Turn Out	#13	ϕ53.1	3207	—
1	1	37	"	" " " " " " "	—	ϕ54.1	3223	—
1	1	38	"	" " " " " " "	—	ϕ67.1	3210	—
1	1	39	"	" " " " " " "	—	ϕ67.3	3244	—
				19 Aug 71				
1	1	40	Semi	Velocity Check FX	—	—	3134	—
1	1	41	"	" " FX	—	—	3162	—
1	1	42	"	" " FX	—	—	3187	—

TEST CONDUCTED BY: Terrell Rekemeyer

AMSWE Form 454, 20 OCT 69

SMALL ARMS TEST DATA RECORD

DATE	TIME	LOCATION	JOB NO.
19 Aug 71		#2	71-65

JOB TITLE: 40mm Gernade Launcher Test

T(°F)	RH(%)	P(InHg)

WEAPON — TYPE: M16A1 with Launcher — SER NO. 800169

AMMUNITION — TYPE: 5.56mm Ball — LOT NO. Ba-2-60

FIXTURE — TYPE: Functioning jack — NO. RIA DA 3784

ROUNDS 42 LOADED	FIRED	TOTAL	TYPE OF FIRE	COMMENTS		Fastax #	Velocity 40mm	Velocity 5.56	sound DB
1	1	43	Semi	STD Projectile BBL 1 turn out with "O" rings.	FX	14	110.3	-	-
1	1	44	"	same as RD #43	FX	-	112.2	3172.0	-
1	1	45	"	same as RD #43	FX	-	115.1	3139.7	154
1	1	46	"	Same As RD #43	FX	-	117.9	3095.9	-
1	1	47	"	Same as RD #43	FX	-	113.8	3137.2	-
1	1	48	"	Same as RD #43	FX	-	110.0	3174.6	-
1	1	49	"	" " " "	FX	-	111.3	-	-
1	1	50	"	STD Projectile BBL 2 turns out, wo/"O" rings	FX	-	106.2	3207.6	-
1	1	51	"	" " " " "	FX		116.2	3164.5	-
1	1	52	"	" " " " "	FX	-	109.3	3129.8	-
1	1	53	"	STD Projectile, BBL ½Turn out wo/"O" rings	FX	-	11.07	3137.2	-
1	1	54	"	" " " " " "	FX	-	116.7	3174.0	-
1	1	55	"	" " " " " "	FX	-	112.7	3184.7	-
				20 Aug 71					
1	1	56	"	556 Rd for Check of Weapon	FX	-	-	-	-
1	1	57	"	" " "" " " "	FX	-	-	3207.6	-
1	1	58	"	STD Projectile w/hv "O" rings 1 Turnout	FX	-	-	3127.4	-
1	1	59	"	5.56Rd for Velocity Check	FX	-	-	3115.0	-
1	1	60	"	Same As RD #58	FX	-	130	3184.7	-
1	1	61	"	" " "	FX	-	-	-	-
1	1	62	"	" " "	FX	-	134.5	3192.3	-
1	1	63	"	" " "	FX	-	133.1	3169.5	-

TEST CONDUCTED BY: Terrell

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SMALL ARMS TEST DATA RECORD

DATE	TIME	LOCATION	JOB NO.
20 Aug 71		# 2	71-63

JOB TITLE: 40MM Grenade Launcher

T(°F)	RH(%)	P(InHg)

WEAPON — TYPE: M16A1 W/Launcher; SER NO. 800169

AMMUNITION — TYPE: 5.56mm; LOT NO. RA-2-60

FIXTURE — TYPE: Functioning Jack; NO. RIA DA 3784

ROUNDS: 63

LOADED	FIRED	TOTAL	TYPE OF FIRE	COMMENTS		Velocity 40mm	Velocity 5.56	Sound DB
1	1	64	Semi	Pre-Engraved Rd w/HV "O" Ring BBL 1 Turn Out	FX	140.9	3210.2	-
1	1	65	Semi	5.56 Rd Check of Instrumentation	FX	-	-	-
1	1	66	Semi	5.56 Rd Check of Instrumentation	FX	-	3164.5	-
1	1	67	Semi	Pre-Engraved Rd w/HV "O" Ring BBL 1 Turn Out	FX	148.9	3159.5	-
1	1	68	Semi	Pre-Engraved Rd w/HV "O" Ring BBL 1 Turn Out	FX	148.2	3187.2	-
1	1	69	Semi	Std Projectile w/Grease BBL 1 Turn Out	FX	147.1	3210.2	-
1	1	70	Semi	Std Projectile w/Grease BBL 1 Turn Out	FX	155.6	3149.6	-
1	1	71	Semi	Std Projectile w/Grease BBL 1 Turn Out	FX	157.2	3159.5	-
1	1	72	Semi	Std Projectile Urethan Dipped BBL 1 Turn Out	FX	135.2	3172.0	-
1	1	73	Semi	5.56 Check of Instrumentation	FX	-	3197.4	-
1	1	74	Semi	Same as Round # 72	FX	137.9	3144.6	-
1	1	75	Semi	Std Projectile 1/4 Turn Out	FX	125.3	3189.7	-
1	1	76	Semi	Std Projectile 1/4 Turn Out	FX	125.0	3167.0	-
1	1	77	Semi	Std Projectile 1/2 Turn Out	FX	121.8	3164.5	-
1	1	78	Semi	Std Projectile 1/2 Turn Out	FX	127.8	3169.5	-
1	1	79	Semi	Std Projectile 1/2 Turn Out	FX	121.7	3169.5	-
1	1	80	Semi	Std Projectile Dipped in Eva 1 Turn Out	FX	137.4	3134.7	-
1	1	81	Semi	Std Projectile Dipped in Eva 1 Turn Out		137.5	3194.8	-
1	1	82	Semi	Pre-Engraved w/LSA 1 Turn Out		-	-	-
1	1	83	Semi	5.56 Rd Velocity and Pressure (Pressure Rear Port)		-	3132	-
1	1	84	Semi	5.56 Rd Velocity and Pressure (Pressure Rear Port)		-		-
1	1	85	Semi	5.56 Rd Velocity and Pressure (Pressure Rear Port)		-	3187	-

TEST CONDUCTED BY: Terrell

AMSWE Form 454, 20 OCT 69

SMALL ARMS TEST DATA RECORD

DATE	TIME	LOCATION	JOB NO.
20 Aug 71		# 2	6 71-65

JOB TITLE: 40MM GRENADE LAUNCHER

T(°F)	RH(%)	P(InHg)

WEAPON		AMMUNITION		FIXTURE	
TYPE	SER NO.	TYPE	LOT NO.	TYPE	NO.
M16A1 W/Launcher	800169	5.56	RA-2-60	Functioning Jack	RIA DA 3784

ROUNDS LOADED	ROUNDS FIRED	ROUNDS TOTAL	TYPE OF FIRE	COMMENTS	Velocity 5.56
1	1	86	Semi	5.56 Rd For Velocity and Pressure (Pressure at Rear Port)	3172.0
1	1	87	Semi	5.56 Rd for Velocity and Pressure (Pressure at Front Port)	3189.7
1	1	88	Semi	5.56 Rd For Velocity and Pressure (Pressure at Front Port)	3212.8
1	1	89	Semi	5.56 Rd for Velocity and Pressure (Pressure at Front Port)	-
				TEST STOPPED FOR MODIFICATIONS. TO BE CONTINUED LATER.	

TEST CONDUCTED BY: Terrell

AMSWE Form 454, 20 OCT 69

SMALL ARMS TEST DATA RECORD

DATE	TIME	LOCATION	JOB NO.
16 Sept		# 1	71-65

JOB TITLE: 40MM GRENADE LAUNCHER TEST

T(°F)	RH(%)	P(InHg)

WEAPON — TYPE: M16A1 W/Launcher; SER NO.: 800169

AMMUNITION — TYPE: ; LOT NO. RA-2-60 MA-34-10

FIXTURE — TYPE: Accy Jack; NO.:

ROUNDS LOADED	ROUNDS FIRED	ROUNDS TOTAL	TYPE OF FIRE	FASTEX #-14	VELOCITIES 5.56	VELOCITIES 40mm	COMMENTS M79 Grenade T1835
1	1	90		NA	3144	NA	FX
1	1	91		NA	3142	NA	FX
1	1	92		NA	3164.5	NA	FX
1	1	93		15	3115	170	
1	1	94		16	3123	168	FX
1	1	95		17	3113	169	FX
1	1	96		18	3164	156	FX
1	1	97		19	3180	155	FX
1	1	98		20	3140	154	FX
1	1	99		21	3134	70	FX
							M79
1	1	1		22	NA	231	
1	1	2		23	NA	230	

TEST CONDUCTED BY:

AMSWE Form 454, 20 OCT 69

APPENDIX E

A

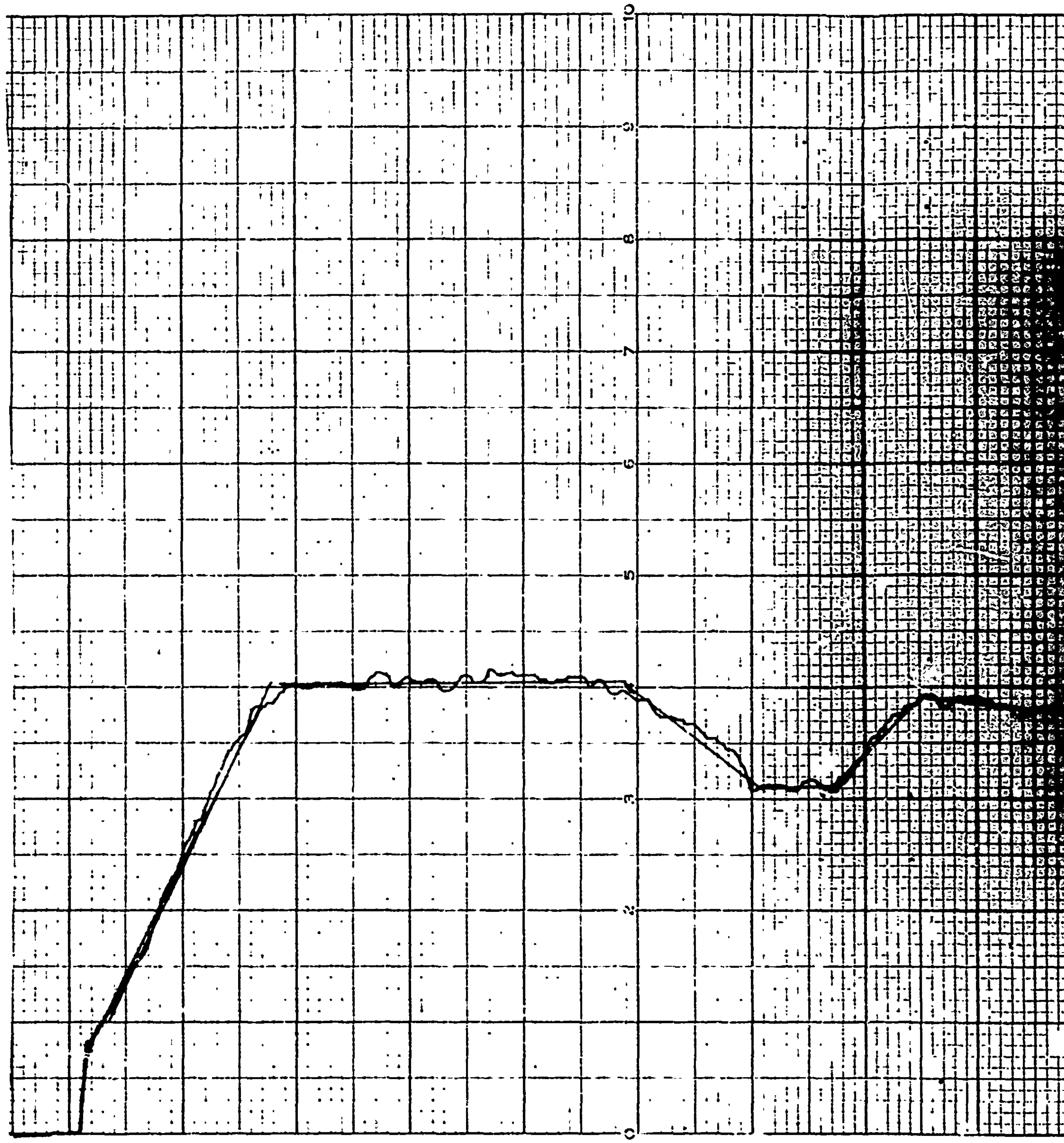
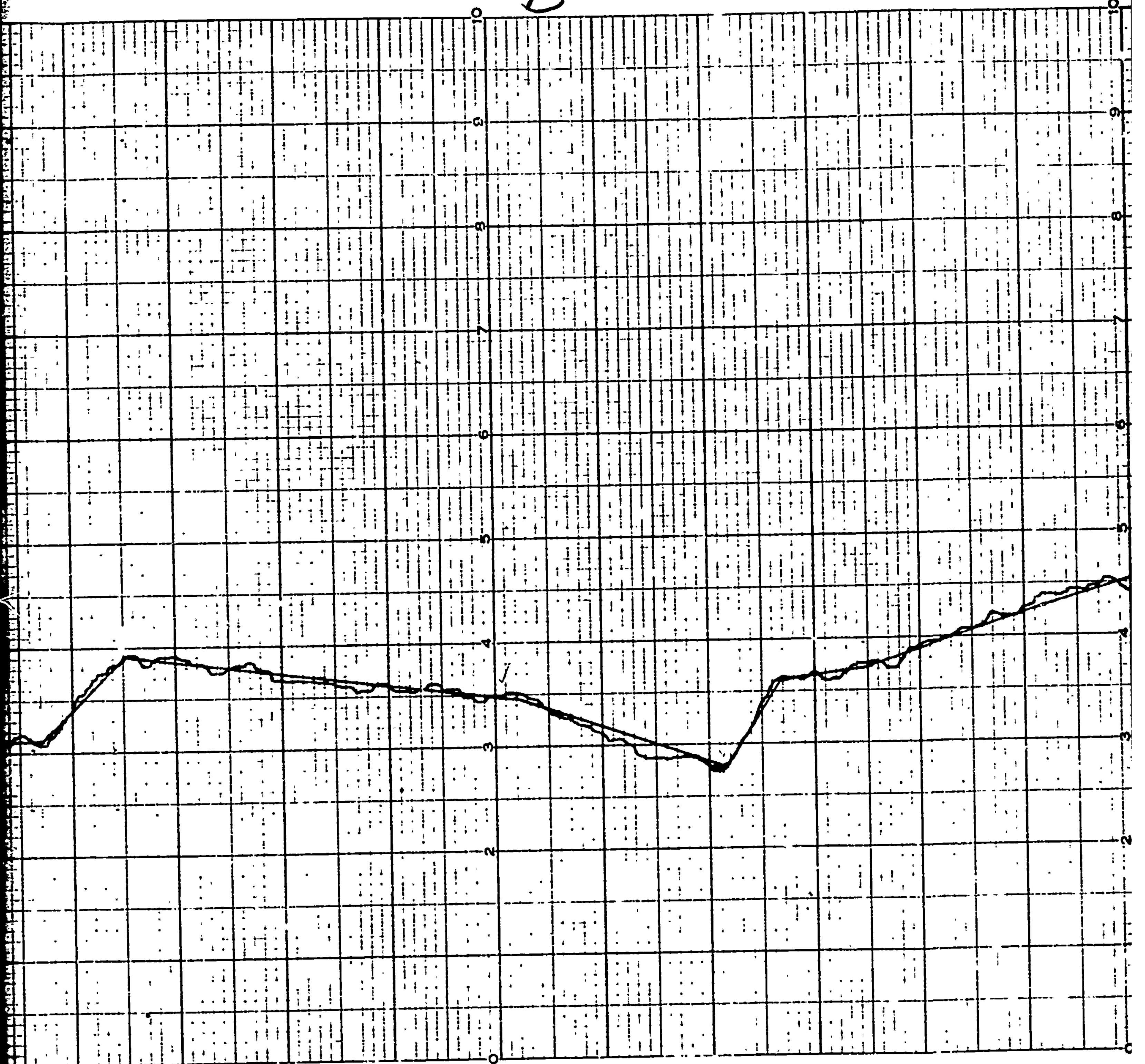
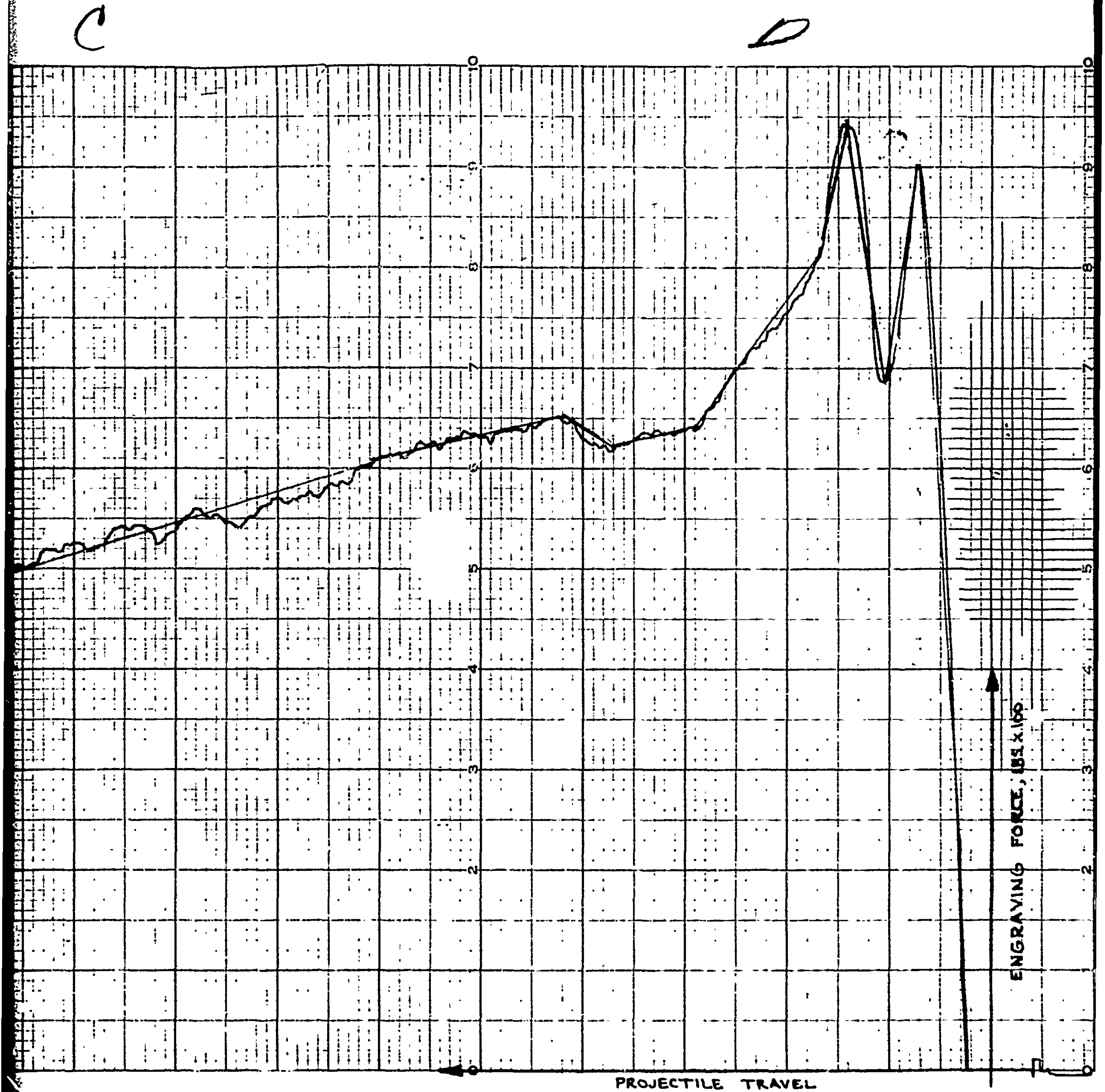


Figure 9: Force/Distance Curve for Barrel Engraving and Friction Forces; .2 in/min

B



Forces;


C
D
ENGRAVING FORCE, LBS X 100
PROJECTILE TRAVEL

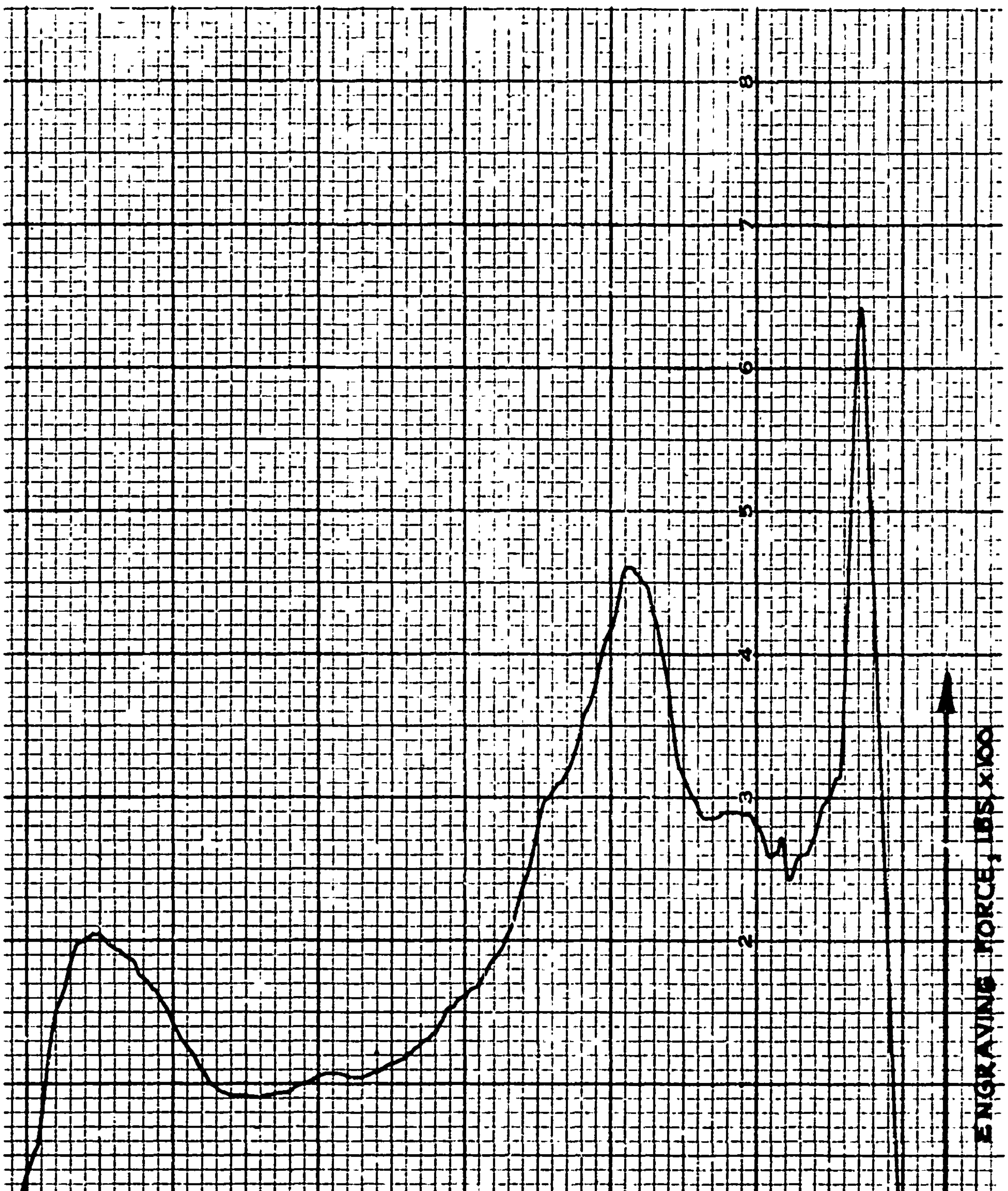
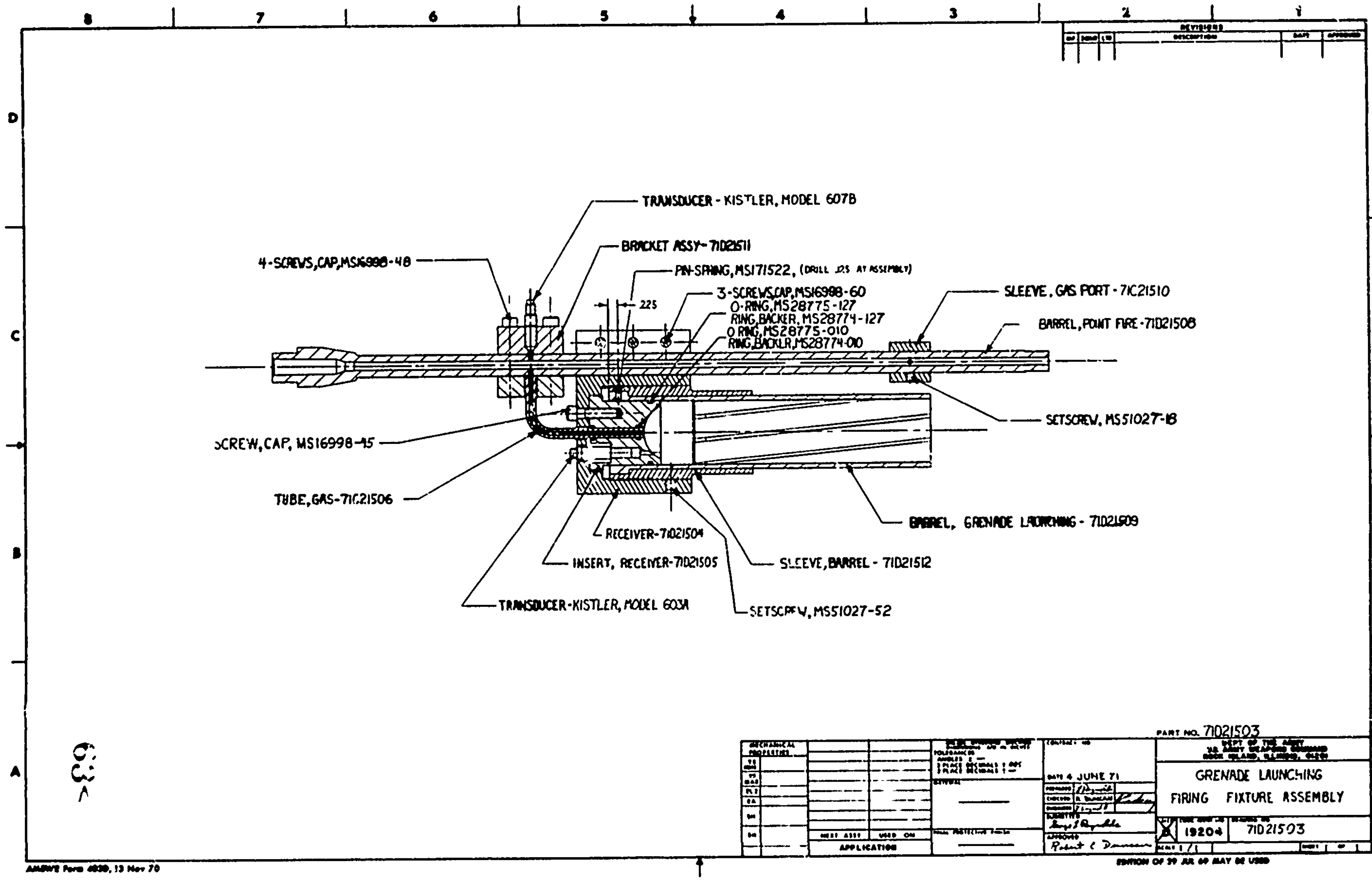


Figure 10: Force/Distance Curve for Barrel Engraving and Friction Forces; 2 in/min

APPENDIX F



TRANSDUCER - KISTLER, MODEL 607B
BRACKET ASSY - 71D21511
4-SCREWS, CAP, MS16998-48
PIN-SPRING, MS171522, (DRILL .125 AT ASSEMBLY)
.225
3-SCREWS, CAP, MS16998-60
O-RING, MS28775-127
RING, BACKER, MS28774-127
O RING, MS28775-010
RING, BACKER, MS28774-010
SLEEVE, GAS PORT - 71C21510
BARREL, POINT FIRE - 71D21508
SETSCREW, MS51027-18
SCREW, CAP, MS16998-45
TUBE, GAS-71C21506
BARREL, GRENADE LAUNCHING - 71D21509
RECEIVER-71D21504
INSERT, RECEIVER-71D21505
SLEEVE, BARREL - 71D21512
TRANSDUCER-KISTLER, MODEL 603A
SETSCREW, MS51027-52
REVISIONS
DESCRIPTION
DATE
APPROVED
D 71D21503
PART NO. 71D21503
GRENADE LAUNCHING
FIRING FIXTURE ASSEMBLY
DATE 4 JUNE 71
19204
71D21503
APPLICATION
NEXT ASSY
USED ON
MECHANICAL PROPERTIES
EDITION OF 29 JUL 69 MAY BE USED
AMSWE Form 4030, 13 Nov 70

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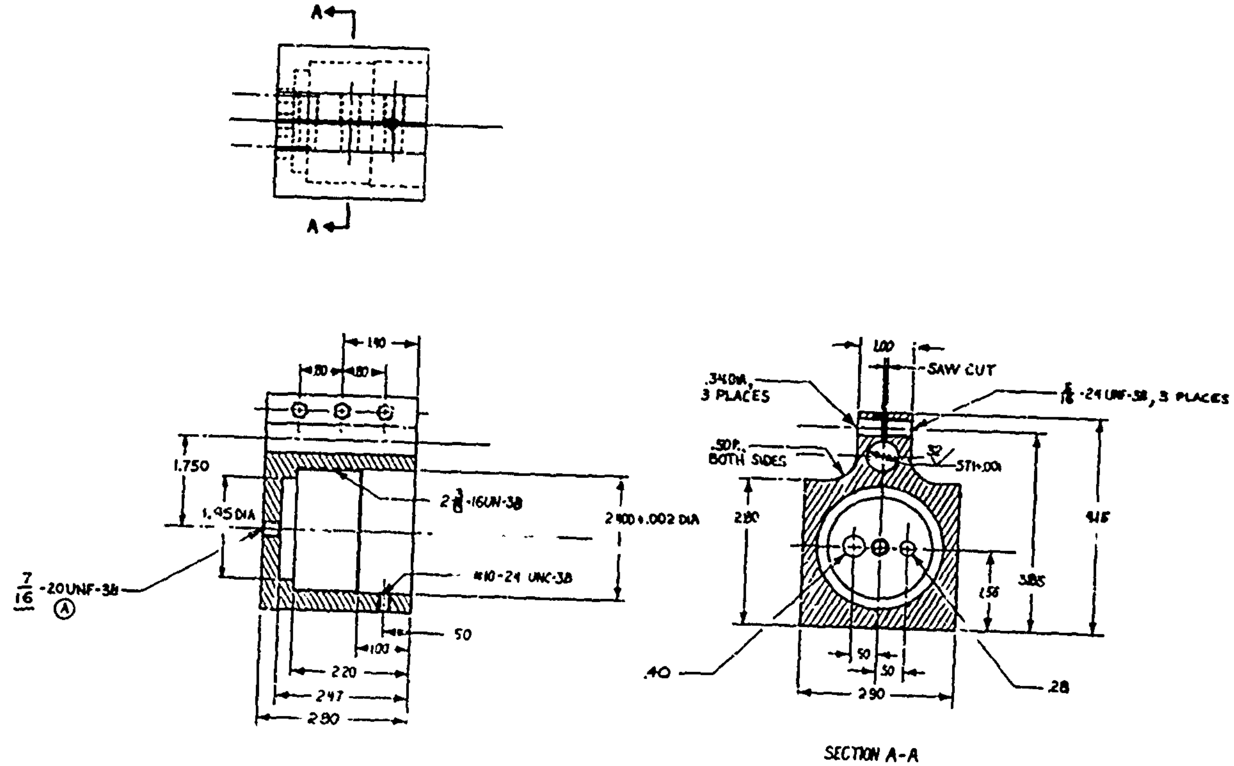
NOTES:
1. FINISH 125 UNLESS OTHERWISE SPECIFIED.
2. ALL EDGES SHALL BE BROKEN .005+.010 UNLESS OTHERWISE SPECIFIED.
3. MATERIAL: STEEL, COMP 1020, QQ-S-634
4. FINAL PROTECTIVE FINISH: APPLY A LIGHT COAT OF OIL, FED SPEC VV-L-800



PART NO. 71D21504

RECEIVER

SEE NOTE 3.

SEE NOTE 4.

71D21503 GRENADE LAUNCHING FIXTURE ASSY

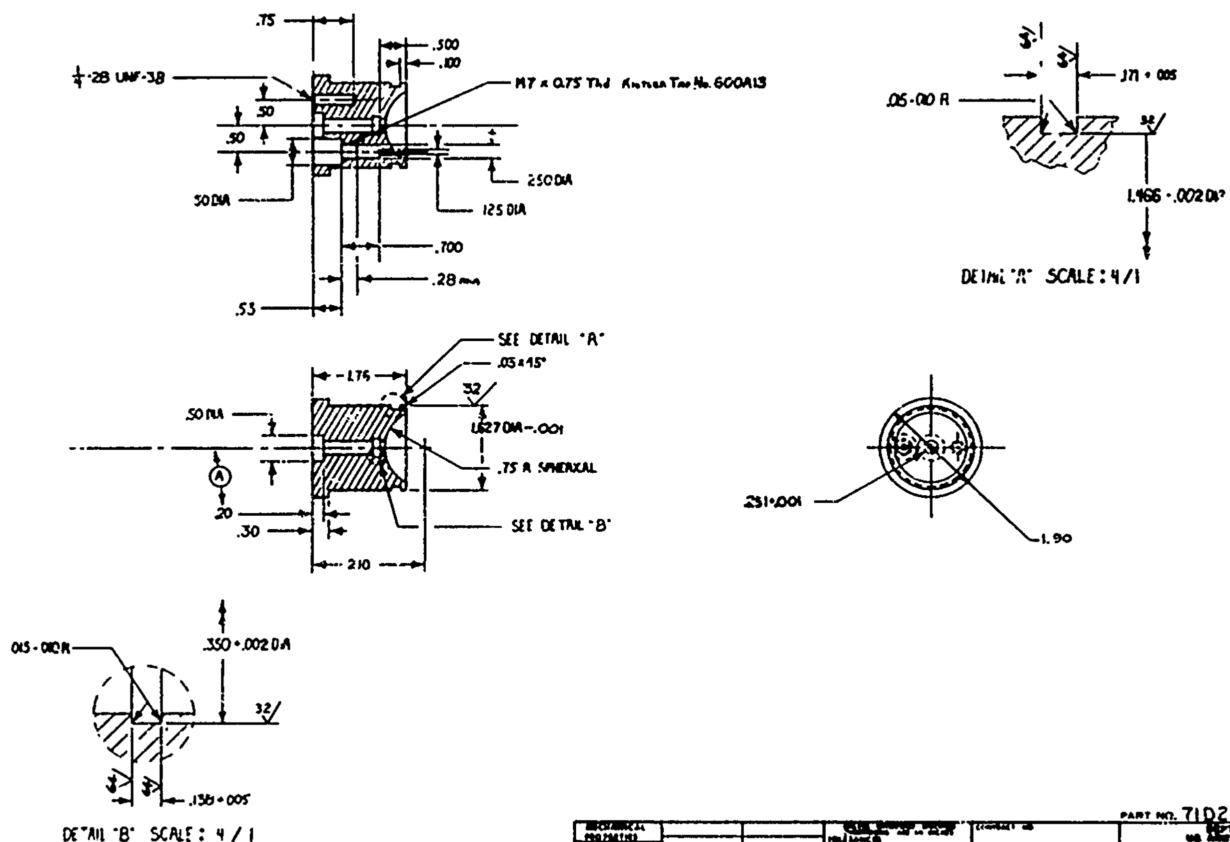
APPLICATION

DATE 4 JUNE 71

19204 71D21504

AMRWE Form 4020, 13 Nov 70

NOTES.
1. FINISH 125/ UNLESS OTHERWISE SPECIFIED.
2. ALL EDGES SHALL BE BROKEN .005+.010 UNLESS OTHERWISE SPECIFIED.
3. MATERIAL: STEEL, COMP 1020, QQ-S-634
4. FINAL PROTECTIVE FINISH: APPLY A LIGHT COAT OF OIL, FED SPEC VV-L800



65

PART NO. 71D21505

INSERT, RECEIVER

NEXT ASSY	71D21503
USED ON	GRENADE LAUNCHING FIXING FIXT
APPLICATION	

SEE NOTE 3.

SEE NOTE 4.

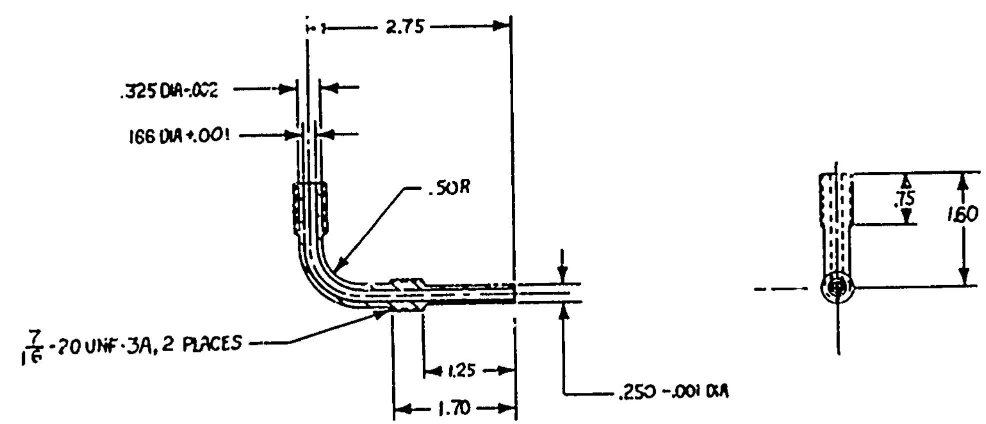
DATE 4-JUNE 71

19204 71D21505

D 71D21505

LTR	DESCRIPTION	DATE	APPROVED
A	SUPERCEDES 71C21506 DATED JUNE 1971	19 OCT. 1971	R. B.

NOTES:
1. FINISH $^{125}\sqrt{}$ UNLESS OTHERWISE SPECIFIED.
2. ALL EDGES SHALL BE BROKEN .005+.010 UNLESS OTHERWISE SPECIFIED.
3. MATERIAL: STEEL, COMP 1020, QQ-S-634
4. FINAL PROTECTIVE FINISH: FINISH 5.3.1.2 OF MIL-STD-171. DO NOT FINISH INTERIOR



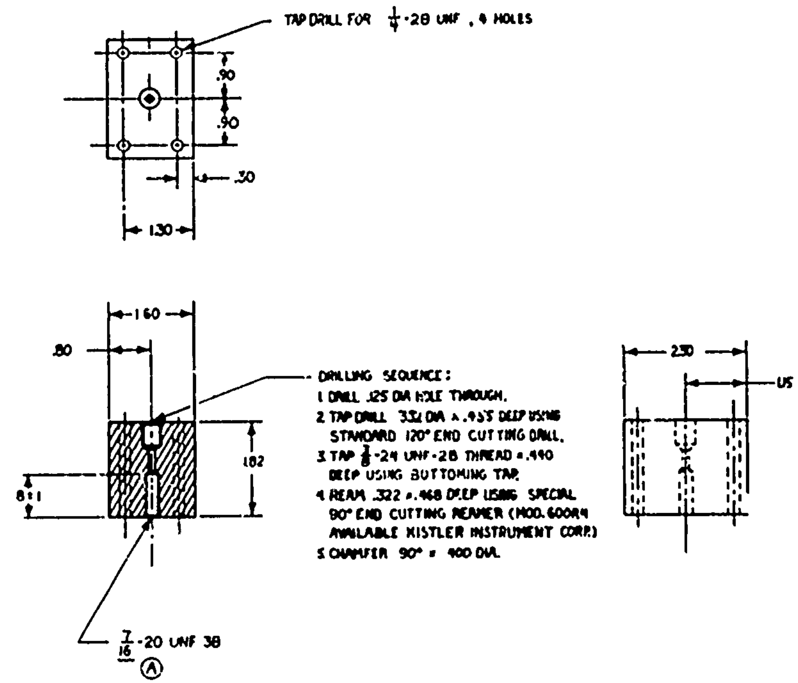
MECHANICAL PROPERTIES			UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ANGLES ± 1° 3 PLACE DECIMALS ± .005 2 PLACE DECIMALS ± .01	CONTRACT NO	PART NO. DEPT OF THE ARMY U.S. ARMY WEAPONS COMMAND ROCK ISLAND, ILLINOIS, 61201
	71D21511	BRACKET ASSY	MATERIAL SEE NOTE 3.	DA · OCT 1971	TUBE, GAS
	NEXT ASSY	USED ON	FINAL PROTECTIVE FINISH SEE NOTE 4		CODE IDENT NO 19204 — DRAWING NO 71C21506
	APPLICATION				SCALE 1/1 — SHEET OF

AMSWE Form 403C, 13 Nov 70

EDITION OF 29 JUL 69 MAY BE USED.

C71C21506

NOTES:
1. FINISH 125 UNLESS OTHERWISE SPECIFIED
2. ALL EDGES SHALL BE BROKEN .005-.010 UNLESS OTHERWISE SPECIFIED
3. MATERIAL: STEEL, COMP 1010, QQ-S-634
4. FINAL PROTECTIVE FINISH: APPLY A LIGHT COAT OF OIL, FED SPEC VV-L-800



PART NO	71D21507
DATE	4 JUNE 71
	BRACKET
	13204
	71D21507
	SEE NOTE 3
	SEE NOTE 4.
	BRACKET ASSY
	APPLICATION

D71D21507

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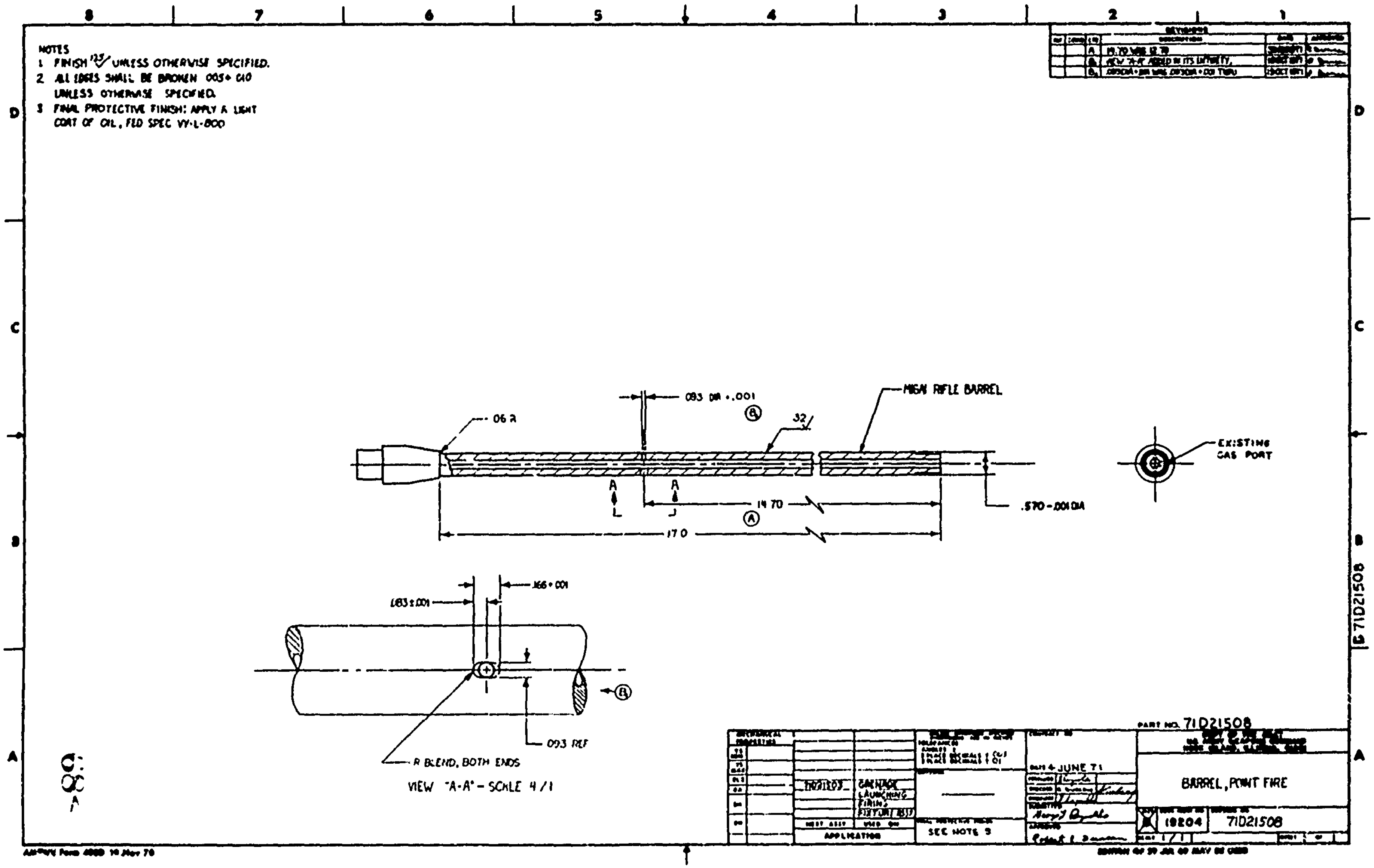
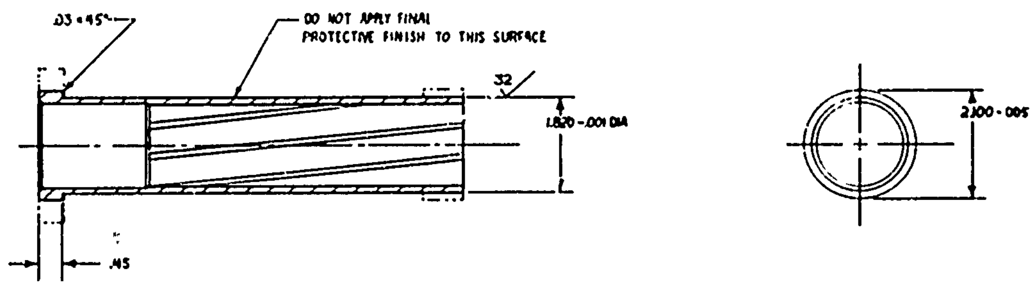

NOTES
1 FINISH 125 UNLESS OTHERWISE SPECIFIED.
2 ALL EDGES SHALL BE BROKEN .005+.010 UNLESS OTHERWISE SPECIFIED.
3 FINAL PROTECTIVE FINISH: APPLY A LIGHT COAT OF OIL, FED SPEC VV-L-800
.093 DIA +.001
B
32
M60 RIFLE BARREL
.06 R
A
A
14.70
A
17.0
.570-.001 DIA
EXISTING GAS PORT
.166+.001
.083±.001
.093 REF
B
R BLEND, BOTH ENDS
VIEW "A-A" - SCALE 4/1
PART NO. 71D21508
BARREL, POINT FIRE
19204
71D21508
DATE 4 JUNE 71
SEE NOTE 3
APPLICATION
71D21507
GAS PORT FIRING FIXTURE
71D21508

NOTES:
1. FINISH 125/ UNLESS OTHERWISE SPECIFIED.
2. ALL EDGES SHALL BE BROKEN .005 + .010 UNLESS OTHERWISE SPECIFIED.
3. FINAL PROTECTIVE FINISH:
ANODIC COATING, TYPE III, CLASS 2, .0025 ± .0005 THICK, MIL-A-8625, SEALED 10 MIN IN 180° F, 1 1/4 % AQUEOUS SOLUTION CONTAINING NICKEL ACETATE AND THEN 2 MIN IN 4 1/8 % AQUEOUS SOLUTION OF SODIUM DICHROMATE. COLOR BLACK, NO. 37038 TO DARK GRAY NO. 36081 OF FED-STD-595.
THE FOLLOWING ANODIC COATINGS ARE APPROVED
A. MARTIN HARDCOAT
B. ALUMILITE 226
C. HARDAS
E. SANFORD
APPLY FINAL PROTECTIVE FINISH TO INSIDE OF BARREL ONLY.



REVISIONS

PART NO. 71D21509

DEPT OF THE ARMY
US ARMY WEAPONS COMMAND
ROCK ISLAND, ILLINOIS

BARREL, GRENADE LAUNCHING

CODE IDENT NO. 19204 DRAWING NO. 71D21509

SCALE 1/1

DATE 4 JUNE 71

FINAL PROTECTIVE FINISH: SEE NOTE 3.

NEXT ASSY 71D21503 USED ON GRENADE LAUNCHING ...

APPLICATION

MECHANICAL PROPERTIES

AMSWE Form 4830, 13 Nov 70

EDITION OF 29 JUL 69 MAY BE USED

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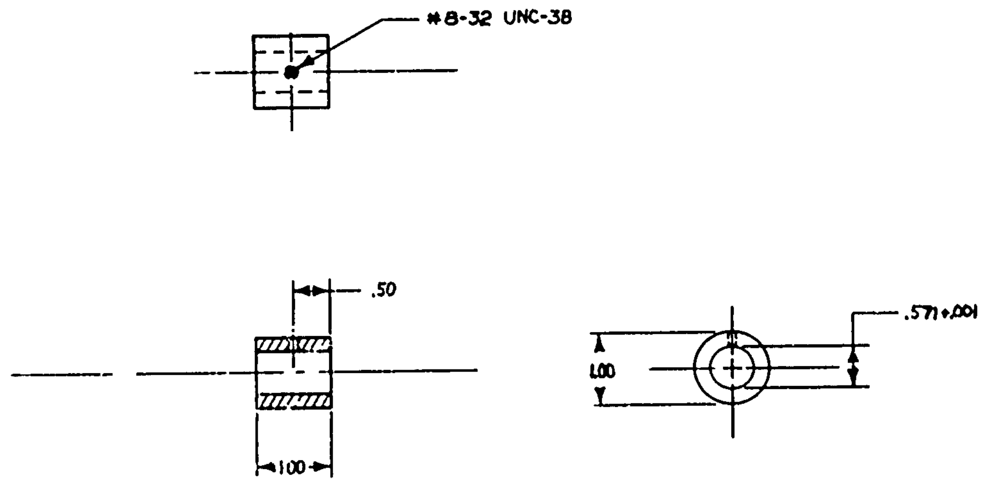
NOTES:
1. FINISH 125 UNLESS OTHERWISE SPECIFIED.
2. ALL EDGES SHALL BE BROKEN .005+.010 UNLESS OTHERWISE SPECIFIED.
3. MATERIAL: STEEL, COMP 1020, QQ-S-634
4. FINAL PROTECTIVE FINISH: APPLY A LIGHT COAT OF OIL, FED SPEC VV-L-800



REVISIONS

SYM	ZONE	LTR	DESCRIPTION	DATE	APPROVED

PART NO. 71C21510

MECHANICAL PROPERTIES	
NEXT ASSY	71C21503
USED ON	GRENADE LAUNCHING FIRING FIXTURE ASSY
	APPLICATION
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES: ANGLES ± —; 3 PLACE DECIMALS ±.005; 2 PLACE DECIMALS ±.01	
MATERIAL	SEE NOTE 3.
FINAL PROTECTIVE FINISH	SEE NOTE 4.
CONTRACT NO	
DATE	4 JUNE 71
PREPARED	J. Reynolds
CHECKED	E. Duncan
ENGINEER	J. Reynolds
SUBMITTED	George J. Reynolds
APPROVED	Robert E. Duncan

DEPT OF THE ARMY
U.S. ARMY WEAPONS COMMAND
ROCK ISLAND, ILLINOIS, 61201

SLEEVE, GAS PORT

SIZE	CODE IDENT NO	DRAWING NO
C	19204	71C21510
SCALE 1/1		SHEET 1 OF 1

C 71C21510

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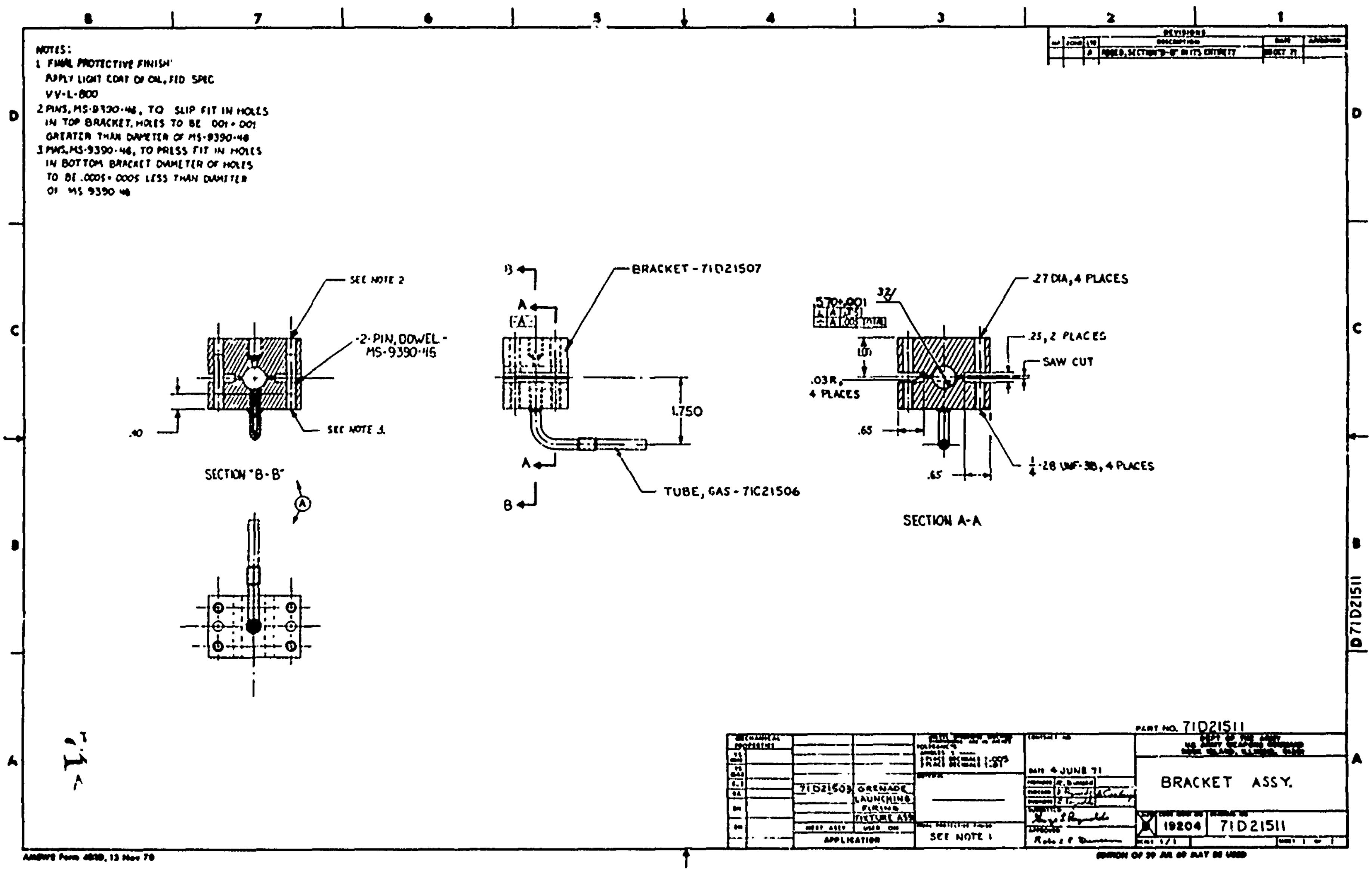
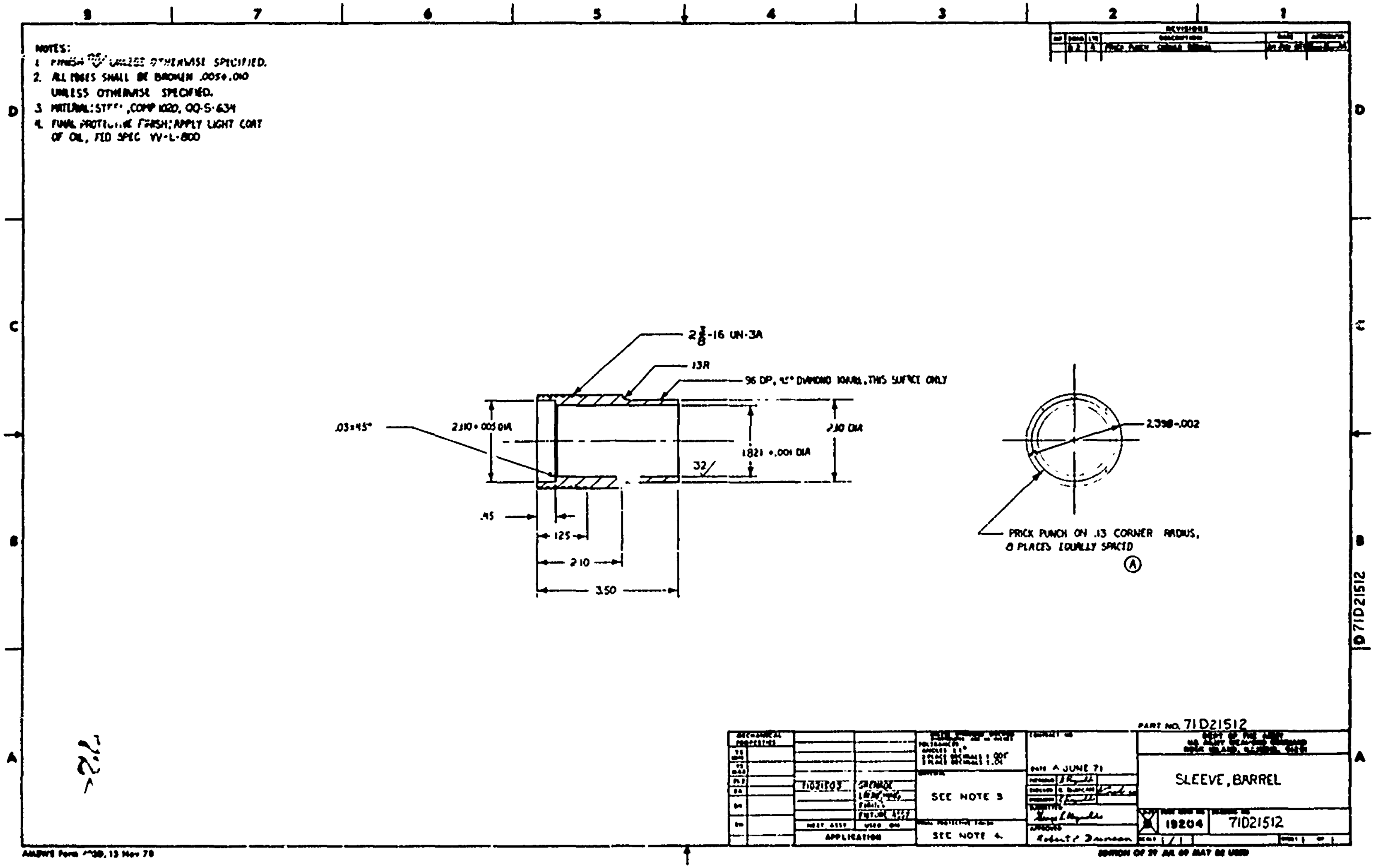
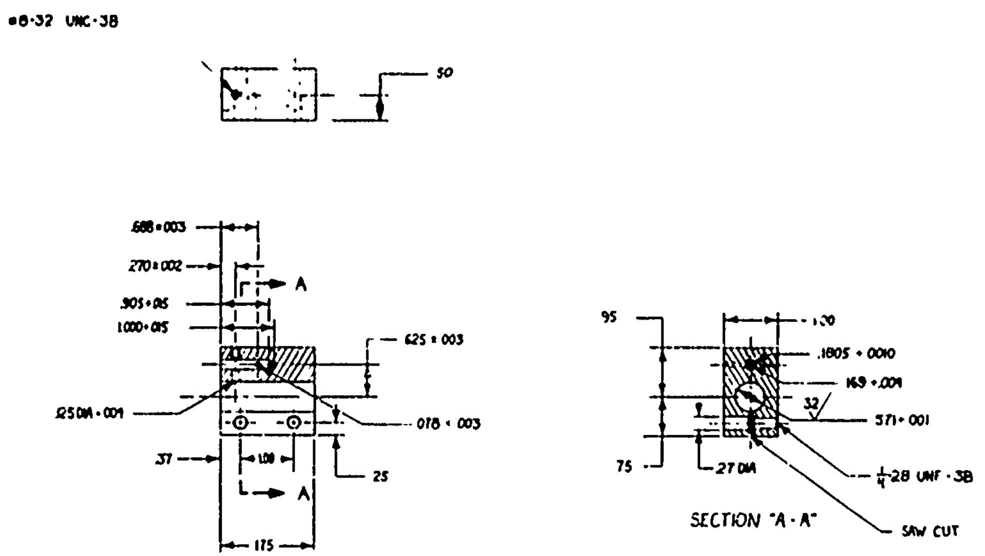
AMSWE Form 403C, 13 Nov 70

EDITION OF 29 JUL 69 MAY BE USED.


NOTES:
1. FINAL PROTECTIVE FINISH
APPLY LIGHT COAT OF OIL, FED SPEC
VV-L-800
2 PINS, MS-9390-46, TO SLIP FIT IN HOLES
IN TOP BRACKET, HOLES TO BE .001+.001
GREATER THAN DIAMETER OF MS-9390-46
3 PINS, MS-9390-46, TO PRESS FIT IN HOLES
IN BOTTOM BRACKET DIAMETER OF HOLES
TO BE .0005+.0005 LESS THAN DIAMETER
OF MS 9390-46
SEE NOTE 2
-2-PIN, DOWEL-
MS-9390-46
SEE NOTE 3
.40
SECTION "B-B"
BRACKET - 71D21507
1.750
TUBE, GAS - 71C21506
.27 DIA, 4 PLACES
.25, 2 PLACES
SAW CUT
.03 R, 4 PLACES
.65
.65
1/4-28 UNF-3B, 4 PLACES
SECTION A-A
PART NO. 71D21511
BRACKET ASSY.
19204
71D21511
71D21503
GRENADE LAUNCHING FIRING FIXTURE ASSY
APPLICATION
SEE NOTE 1
DATE 4 JUNE 71
D71D21511


NOTES:
1. FINISH UNLESS OTHERWISE SPECIFIED.
2. ALL EDGES SHALL BE BROKEN .005+.010 UNLESS OTHERWISE SPECIFIED.
3. MATERIAL: STE.. ,COMP 1020, QQ-S-634
4. FINAL PROTECTIVE FINISH: APPLY LIGHT COAT OF OIL, FED SPEC VV-L-800
$2\frac{3}{8}$-16 UN-3A
.13R
96 DP, 45° DIAMOND KNURL, THIS SURFACE ONLY
.03×45°
2.310+.005 DIA
2.30 DIA
1.821+.001 DIA
32
.45
.125
2.10
3.50
2.398-.002
PRICK PUNCH ON .13 CORNER RADIUS, 8 PLACES EQUALLY SPACED
A
SEE NOTE 3
SEE NOTE 4
APPLICATION
A JUNE 71
PART NO. 71D21512
SLEEVE, BARREL
19204
71D21512
D 71D21512
72

NOTES:
1. FINISH 125/ UNLESS OTHERWISE SPECIFIED.
2. ALL EDGES SHALL BE BROKEN .005+.010 UNLESS OTHERWISE SPECIFIED
3. MATERIAL: STEEL, COMP 1020, QQ-S-634
4. FINAL PROTECTIVE FINISH: APPLY A LIGHT COAT OF OIL, FED SPEC VV-L-800



PART NO. 71D21580

GAS TUBE BRACKET, RIFLE

19204 71D21580

DATE 11 JUNE 1971

71D21503 CARBINE LAUNCHING FIRING FIXTURE ASSY

NEXT ASSY USED ON

APPLICATION

SEE NOTE 3.

SEE NOTE 4.

D 71D21580

AMSWE Form 4830, 13 Nov 70

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